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RETURN TO 207 MARKET ST.
GENERAL
SUPERINTENDENT'S
OFFICE,

PIPING A SMALL STEAM PLANT

BY W. H. WAKEMAN.

Some time ago I visited the engine and boiler room of a shop, on business with the engineer, and while there I was much pleased with the evidence of good judgment and care shown by the way in which valves were selected and located,

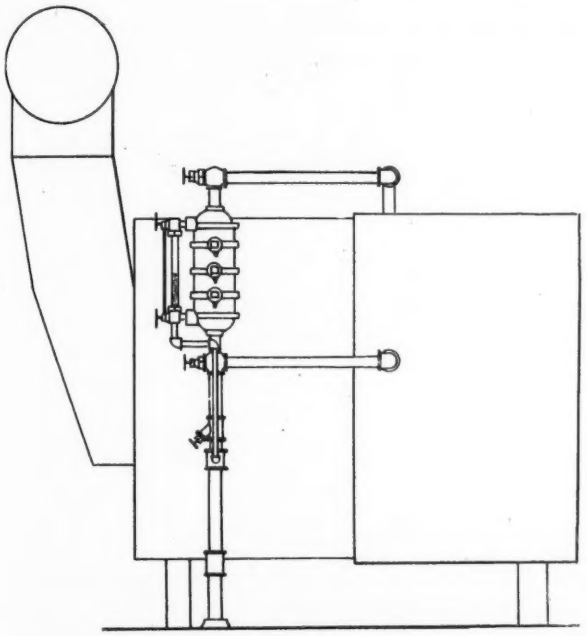

Fig. 1

also the fine arrangement of several appliances used in this plant.

While there is nothing new and untried in this plant, still it is worthy of special mention by way of contrast with others that are in evidence, also as an example for other engineers who may be allowed to plan and execute work along this line.

An internally fired boiler is used here, and the makers located connections for the water column far enough away from the front to avoid the disturbing influence of violent boiling of the water directly above the furnace, which is proper, but this would bring the gauge glass in a dark spot between the boiler and a brick wall, making an undesirable combination. To avoid this ells were used and the piping extended as shown in Fig. 1, thus bringing the gauge glass where it can easily be seen at all times.

Fig. 2 shows the front of this boiler with its fixtures. The upper connection is provided with an angle valve, and the lower with a cross valve for shutting off the column at night. Below the cross there is a Y valve which provides an almost straight passage for blowing sediment out of the pipes and

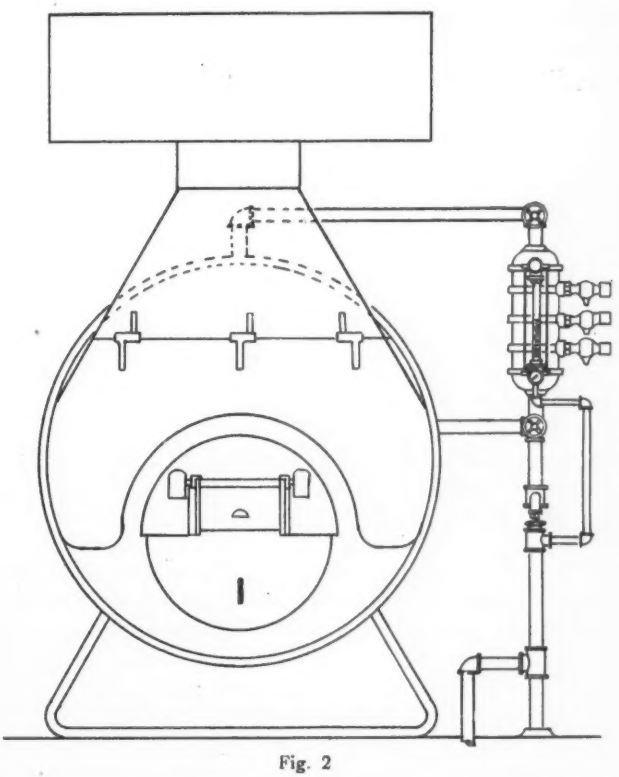

Fig. 2

columns and is free from the objectionable features of a gate valve as it can be quickly opened or closed, and is easily repaired. The ordinary pet cock found in many water gauges was removed and a globe valve substituted as being much less

liable to leak and the small pipe from it is connected into the sewer pipe below the Y valve.

This pipe is continued down to the floor and terminates in a floor plate which rests on a suitable foundation. Above this

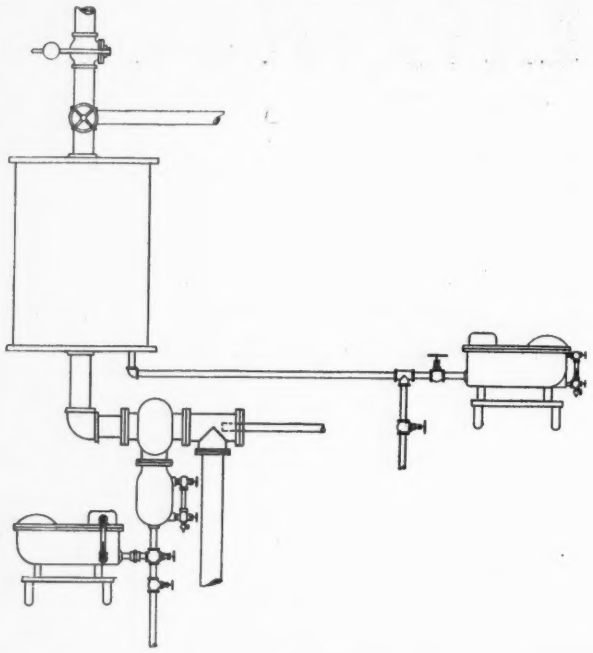

Fig. 3

plate there is a tee the outlet from which forms a passage to the sewer. The short horizontal pipe also forms a convenient place for fire tools to rest upon, raising their handles above the floor so that they can be easily reached.

Fig. 3 shows the arrangement of heater, exhaust pipe and appliances. The heater is located in a corner of the boiler room, but is several feet above the floor, therefore it occupies room that would not be used for other purposes. This plan renders the space under the heater available for other machinery.

A horizontal separator was wanted for this place, therefore it became necessary to connect it as shown. The main exhaust pipe comes from beneath the floor and enters this separator by means of a tee, the outer end of which is bushed to receive the exhaust pipe from several pumps. This pipe is ar-

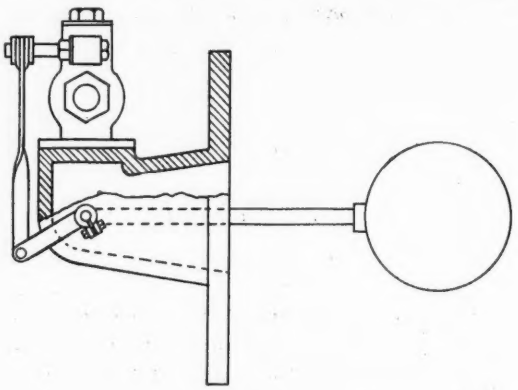

Fig. 4

ranged so that when steam is discharged from it, no obstruction is offered to free passage of steam through the main exhaust pipe, but on the contrary it is forced onward by the exhaust steam from pumps.

There is a water gauge on this separator which shows the water level at all times. Connection is made by means of a cross valve, three nipples and a union to a trap of the continuous discharge type. In winter this cross valve is open, and the drip valve below is closed, in order to prevent steam from going to the sewer while there is pressure on the heating

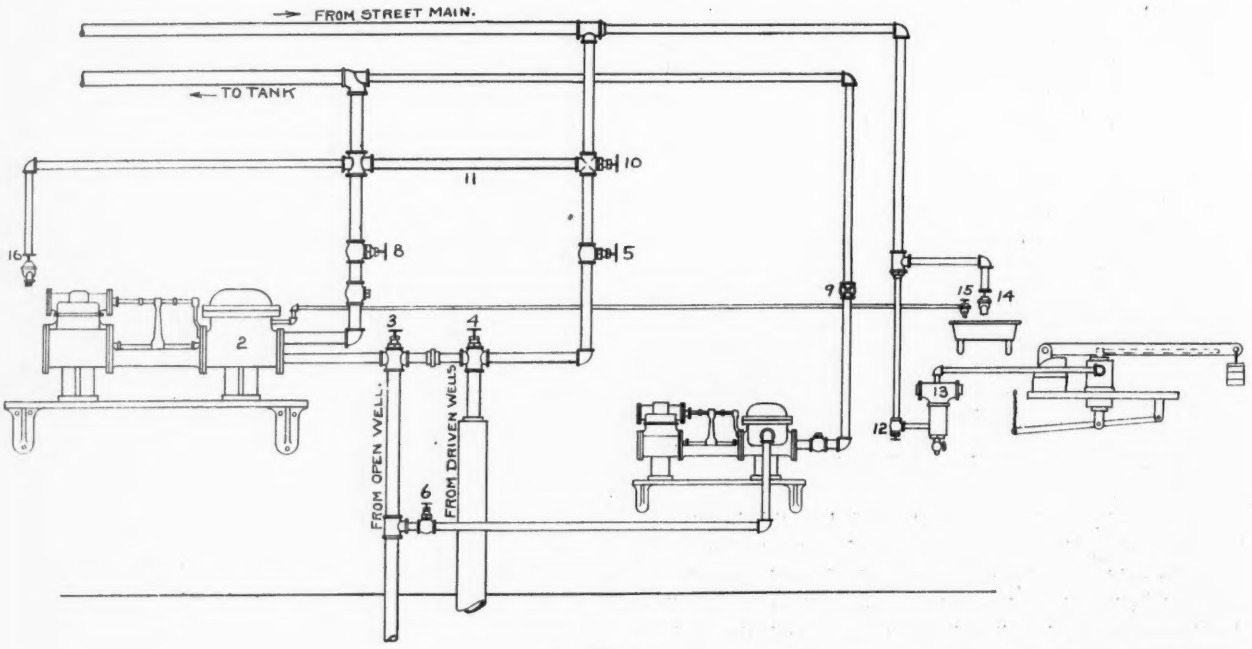

Fig. 6

system. All water and grease are removed by the trap and discharged to the sewer through a pipe not shown. A water gauge is also provided here to indicate the water level. This is important because it also indicates whether the trap is working correctly or not.

In summer when there is no pressure on the heating system, this trap is shut off by means of the cross valve, thus allowing grease and water to go directly to the sewer.

All steam that reaches the heater is pure, therefore all that is condensed by heating feed water is fit for boiler feeding. The drip shown conveys this water to a trap which in turn discharges it into a receiver through a pipe not shown, from which it is taken and pumped into the boiler. All of these repairs, it may be shut off by 3 and all water allowed to flow through 6 to the sewer.

Water under high pressure returns from a system of heating glue pots, etc., through the pipe 7 and angle valve 8 to the trap 9 from which it is discharged through 10 to a header and thence to the receiver. This header is provided with other inlets that will be required for future use.

In case the trap 9 needs repairs, pressure may be shut off at 8 and all water sent to the sewer through 11.

As this is not sufficient to feed the boiler at all times, water from the street main is admitted through 12 while 13 is closed. Hot water from this receiver is admitted through 14 to the tee 15 passing down through a pipe located behind

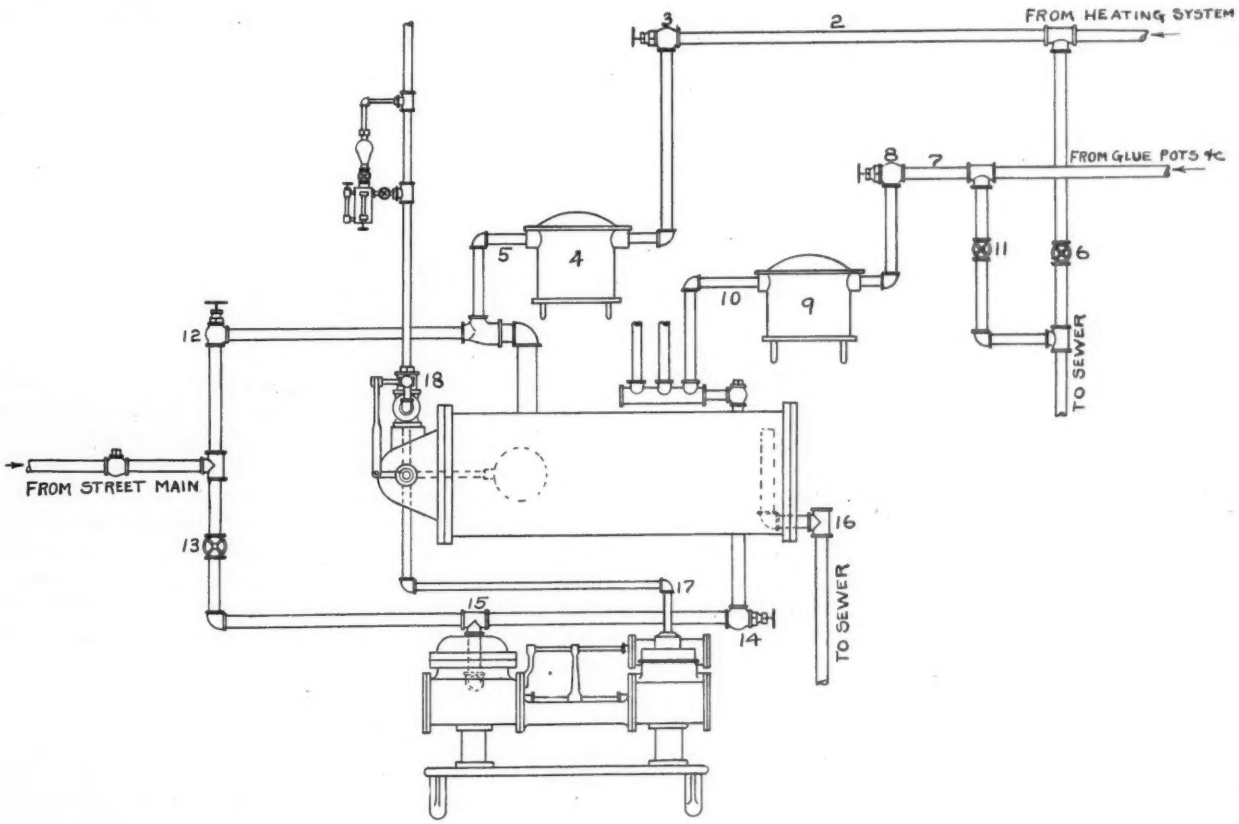

Fig. 5

details are important where water has to be bought by meter measurement. This trap may be shut off at pleasure by the valve shown while water is allowed to escape through the lower valve to the sewer.

In many plants these traps are not considered necessary, as drip valves are called "good enough" but it is not practical for an engineer to adjust these valves so as to save all steam and allow all water to pass.

Fig. 5 illustrates the boiler feed pump and its connections, taking water from a receiver above it. This receiver was made by removing the coil from an old heater and supporting the shell on suitable brackets fastened to a brick wall.

This receiver is supplied with water as follows: Condensation from the heating system at low pressure returns through the pipe 2 and the angle valve 3 to the trap 4 which discharges through 5 to the receiver. In case the trap 4 needs the pump to its suction inlet. If at any time more water comes to the receiver than the pump takes, it goes through 16 to the sewer. This extends to the upper part of receiver as indicated by dotted lines. The upper part of tee 16 is left open so that the flow of water, or absence of it may be observed.

When it is desired to use all cold water from the street main, 12 and 14 are closed and 13 opened, thus "cutting out" the receiver entirely.

The makers of this pump provided an inlet at the side of the steam chest for connecting the live steam pipe with another on top for a single connection lubricator, but this was not satisfactory, therefore the steam pipe was connected as shown at 17 and a double connection sight feed lubricator attached to this steam pipe above the receiver.

This plan causes cylinder oil to pass through the automatic regulating valve 18 causing it to operate easily and increas-

ing its durability, for steam that is saturated with good cylinder oil does not wear an automatic valve as rapidly as when oil does not pass through it. The objection to this plan is that with some kinds of automatic regulating valves, a portion of the oil drops into the receiver and from thence finds its way into the boilers, but this is impossible with this valve which is better illustrated in Fig. 4 which shows a round float connected by means of levers to a balanced valve through which steam passes, but the lower part of this valve is a solid casting and there is no passage through it into the receiver, therefore oil cannot leak into it.

Fig. 6 shows the arrangement of pumps and piping for supplying the shop with water. The pump 2 draws water from an open well through a cross valve 3, also from a system of driven wells through a cross valve 4 when 5 is closed. By closing either 3 or 4, water is drawn through the other only. Closing both 3 and 4 and opening 5 causes the pump to take water under pressure from the street main.

This combination enables the engineer to draw water from wells as long as the supply lasts, saving expense due to buying water from a street main, but the latter is available when needed.

When 4 is open and 3 closed, the pump 2 draws water from driven wells, then if 6 is opened the pump 7 will draw water from an open well and both pumps discharge into an elevated tank.

If there is no water in these wells, then by closing 5, 8 and 9 and opening 10, water under pressure comes from street main, passes through pipe 11 and is discharged into the tank, provided there is enough pressure to carry it there, which is not always the case.

Water for operating the damper regulator is taken from the street main through an angle valve 12 passing through a sediment chamber 13 on the way. A valve 14 is provided for drawing water from the same source for washing purposes, or it may be taken from the well water supply through 15.

A hose bibb is shown at 16 to which a hose is attached for wetting down ashes, etc., as this piping is located in the boiler room. Special attention is called to the excellent arrangement of cross and angle valves in this plant.

THE CENTRIFUGAL PUMP

Principles of Design and Methods of Application and Operation

The use of the centrifugal pump has increased very rapidly during the past half a dozen years, especially for irrigation, for handling liquids containing solids in suspension, for cofferdam and excavating work, for dredging, for pumping out dry-docks, for circulating condensing water and for ice and refrigerating plants.

As the steam turbine was the first design of a steam engine, so was the centrifugal pump the first pump to be used for pumping water, and, like the steam turbine, it was abandoned in favor of the reciprocating machine until a later period when its uses and application began to be appreciated.

It is said that the earliest history of the centrifugal pump dates back to the middle of the seventeenth century, when the mathematician Euler brought out a primitive form of centrifugal pump. From that period many rotary and centrifugal pumps were designed by French engineers, notably Papin, who in 1703, designed a centrifugal pump embodying nearly all the essential features of the present-day machine. Nothing, however, seems to have been done commercially until 1851, when Appold exhibited his pump at the Exhibition, in London, in that year. This pump was the centre of interest as it tripled the efficiency of any pump then in operation and was productive of many experiments, which resulted in improving the pump until it has assumed its present-day form.

The construction of the centrifugal pump is exceedingly simple, consisting of a revolving disc having two or more blades, either straight or curved, attached to a revolving spindle and fitted in a case or shell so constructed that the suction shall enter at the centre of the wheel and the delivery placed tangent to the outer path of the revolving blades. The experiments made with Appold's centrifugal pump showed that its efficiency mainly depended upon the form of the blades of the fan and that the increase in efficiency between radial and curved vanes was more than doubled in favor of the latter.

The early centrifugal pumps were made with straight flat vanes which discharged into a chamber of more or less conventional form. The result was excessive internal friction. In centrifugal pumps the main object is to pass the water through the pump with as little whirling velocity as possible because the power thus absorbed is not given out again.

Fig. 1 shows a section and Fig. 2 the side elevation of a centrifugal pump that has been extensively used for dredging purposes. It consists of a central shaft upon which a fan, formed of three vanes or blades, is keyed. The fan or vanes are enclosed in a casing that is tight with the exception of two openings. The one A, at the centre and opposite the end of the shaft, serves as a connection for the suction pipe. The opening B, at the bottom and left, leading off tangentially, is the one for the delivery. The vanes of the fan do not touch the side or face of the casing, neither do their guards C, that enclose the outer ends of the blades; therefore, as soon as the pump is stopped, the water or liquid flows out of the casing, leaving the interior empty.

In operation the pump runs in the direction indicated by the arrows. When it is first started, the air contained in the case is set whirling and is forced out at the delivery pipe. This creates a partial vacuum within the case, causing the air in the suction pipe to enter through the central opening A, to be in turn blown out at B. The space previously occupied by the air in the suction pipe is taken by the liquid rising from the tank or reservoir, until it finally enters the casing and is drawn around and forced out the exit by the blades.

Usually, however, before starting a centrifugal pump, it is necessary to fill the casing and suction line with the fluid to be pumped, as machines of this kind will not create a vacuum of any amount without first being primed. The methods which are in general use employ either an ejector, a hand pump, or when a foot valve is used, water from some outside source.

When an ejector is used, it is connected to the highest point on the pump casing and either steam, air or water under pressure may be used to produce a vacuum. When a hand pump is used, the discharge valve is closed before the pump is ready to start and by operating the hand pump, a vacuum is produced and the water drawn in filling the suction pipe and

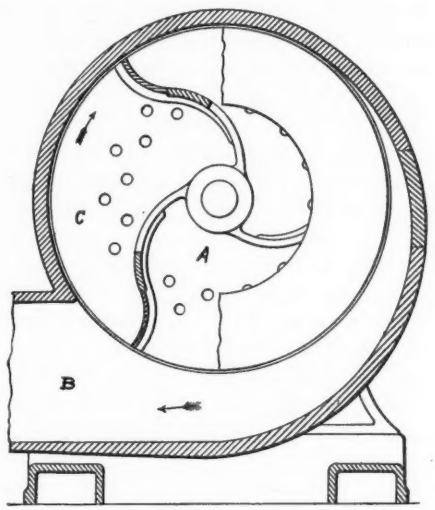

Fig. 1

casing. When a foot valve is used, water is allowed to run into the pump until it reaches the discharge flange, when the supply is cut off and the pump may be started. After the pump has been properly primed, it should be started before the gate valve on the discharge is opened. When full speed is reached, the discharge gate may be slowly opened and the pump will perform its work properly.

The shape of the blades of a centrifugal pump is a matter of great importance when good efficiency is desired. It has been found that the blades should be curved backward relatively to their direction of motion, as shown in Fig. 1. Such a curvature tends to bring the speed of the liquid up to the peripheral speed of the vanes, without giving it a too rapid acceleration by compelling it to follow a radial line, such as would happen if the blades were straight. The passages through the pump must therefore be so proportioned that the liquid will have a gradually increasing velocity from the suction to the delivery. This condition is effected by having a conical end to the suction pipe and to have a spiral casing surrounding the fan.

The speed at which these pumps are run is an important consideration in their economical operation. It is evident that at a very low rate of rotation, a vacuum of sufficient amount to raise the liquid will not be produced and it is only when a sufficiently high velocity has been attained that the pump will begin to work.

In all piston pumps, if the size of the piston and the speed of operation are known, an accurate calculation of the amount of liquid that they will deliver in a given time can be made. With the centrifugal pump these conditions do not prevail because a small increase in the number of revolutions produces a very large increase in delivery. It is, therefore, impossible to calculate in advance the capacity of a centrifugal pump for any rate of revolution. The capacity will not only vary with the speed but it will also vary with the shape of the blades, the shape and internal condition of the casing, the location of the suction and discharge openings, the head to which the water is to be raised and the number and character of the bends in the pipe leading to and from the pump. The rating of the pump must, therefore, be determined experimentally.

There are three classes of centrifugal pumps which are in general use: Conoidal centrifugal pumps, volute centrifugal pumps and turbine pumps. Conoidal centrifugal pumps are designed especially for low lifts and large deliveries and are adapted to irrigation work, the handling of sewage and similar purposes, with heads up to 30 feet. Volute centrifugal pumps are used for medium lifts and are run at moderate speeds. They can be used for heads up to 150 feet. The turbine pump is used for very high lifts up to 2000 feet. The names of the above pumps are derived from the shape of the impeller.

One of the largest uses to which centrifugal pumps are being put is the irrigation of land in the West. The water for irrigation comes from streams, rivers, springs, lakes or wells. The conditions may require large volumes to be pumped long distances, where the head is chiefly due to friction, or the water may be pumped from bored wells or rivers to considerable heights above the source of supply. Mr. J. J. Brown gave some interesting data before the National Irrigation Congress, showing the growth of irrigation for many purposes, as follows:

"In parts of Texas, pump irrigation is meeting with marked success. At the plantation of the Matagorda Company, of Bay City, two 36-inch centrifugals were installed three years

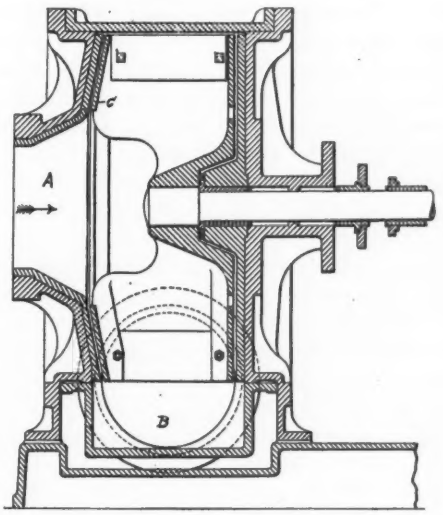

Fig. 2

ago. These pumps deliver 64,000 gallons per minute 12 feet high. The water is drawn from the Colorado River and contains a considerable percentage of sediment and the lift varies with the rise and fall of the river. The pumps are connected by means of rope gearing with a pair of compound condensing engines.

"On the Brazos River, the Brazoria Rice and Irrigation Company have a 36-inch centrifugal, which is located in a masonry pit and delivers 35,000 gallons per minute against a head of 48 feet. The engine driving the pump is at the sur-

face and connection is made by means of a rope drive at an angle of about 45 degrees. The suction lift of the pump, including the friction of the long suction pipe, is at low water about 25 feet, but no trouble has arisen from this high lift. The pump handles water containing a large percentage of sharp sand. No provision has been made for the protection of the intake since the time the pump was installed and, as a result, a considerable amount of quicksand from the surrounding hills has been drawn into the suction pipe and a number of landslides have resulted. During the first two weeks after installation the canal was practically filled with sand for a distance of several hundred yards. Enormous quantities have been delivered into the canal, probably amounting to several thousand cubic yards. At times the Brazos River rises twenty feet above the pump and puts such a pressure upon the stuffing boxes that some of the grit finds its way into the bearings. Although the pump has been in use three years, no repairs have been necessary, and an efficiency of about 70 per cent. has been maintained. This Company has recently installed a second centrifugal pump, which has a suction lift of 12 feet.

"Pump irrigation in the Salinas Valley of California has been developed very profitably over a considerable area. At the Spreckels Sugar Plantation, 3000 acres are irrigated by means of an 18-inch centrifugal pump directly connected to an induction motor. The water is taken from the Salinas River and the total lift averages 30 to 50 feet. Another plantation is owned by the same Company, where 500 acres are irrigated by a centrifugal pump. The average cost is $2.00 per acre per year, running 12 hours, the fuel consumption being ½ cord of wood per acre irrigated. At the Soledad ranch, the cost for irrigation by centrifugal pumps is $2.50 per acre. Pumps are used with a capacity of 8000 to 10,000 gallons per minute. The Soledad Land and Water Company irrigates with a belted centrifugal pump working against heads varying from 14 to 31 feet. This plant irrigates 800 acres and cost $10,000, net, including ditching. In the lower Salinas Valley there are many small pumping plants which pump from deep wells by means of centrifugal pumps and gas engines, the crops being alfalfa, potatoes and vegetables. The aggregate area is approximately 2600 acres.

"In the Hawaiian Islands irrigation has developed a great deal of land that was arid and unproductive, sugar-cane being the most extensive crop. Over 2000 tons of sugar were produced on this land last year, netting the growers $14,000,000. Both gravity and pumping systems are used in the Hawaiian Islands, the latter being necessary in most localities. In the Island of Oahu, which is 12 miles wide and 35 miles long, about 300,000,000 gallons of water are pumped each day from wells reaching a stratum 400 to 800 feet below sea-level. In other islands the water is taken from sumps excavated 5 to 8 feet below sea-level. The pumping plants are usually fed from 12-inch wells 50 feet apart, each well pumping 1,000,000 gallons, ten operating continually and two being held in reserve. The highest head pumped against is 450 feet. In Waianae a waterfall in the mountains supplies electric power, which is used in pumping near the sea-level, directly-connected pumps being used to lift water 15 feet. In Haui the pump capacity is 140,000,000 gallons daily; in Kauai, 55,000,000 gallons daily, and in Hawaii, 7,000,000 gallons. The majority of the pumps have been installed for some time and are of the reciprocating type, but the new installations are entirely high-speed centrifugal pumps. In several cases shafts have been sunk 200 to 300 feet to the water level and directly-connected pumps with long vertical shafts reaching to motors at the surface have been installed.

"For irrigation from bored wells, the best system is to lower a vertical multi-stage turbine pump into the well, the long vertical shaft being arranged in sections so that the pump may be lowered as the water level recedes. The top of the shaft may be driven by either a vertical shaft motor or by belt from an oil or steam engine. This system is now in extensive use in Lower California, where the wells are sometimes over 500 feet deep. Horizontal belt drives are not, as a rule, satisfactory, due to moisture causing the belt to slip and stretch, but when a vertical shaft is employed and the belt arranged wholly above ground, very efficient action may be obtained.

"It may be interesting to note that centrifugal pumps are being used very extensively in processes the reverse of irrigation. In localities where the land is flooded, or the ground saturated through infiltration, rendering cultivation impossible, levees are built enclosing the section to be drained and pumping plants are installed. The usual system is to locate the plant permanently on piles or on ground higher than that to be drained, and by ditching the land radially, bring the water to a central canal, from which it is drawn by the pumps. One method of installation, where islands are to be drained, is to mount the pump on a floating scow, together with a steam or oil engine, and then use a flexible connecting pipe of sufficient length to reach any part of the land, floating the scow around the outside of the dike. However, this arrangement is applicable in a comparatively small number of cases. The cost of draining the land in this way depends, as it does in irrigation, greatly upon local surroundings.

"Reclamation is being carried out on a large scale along the San Joaquin and Sacramento Rivers in California, which have very little fall for the first 200 miles of their courses. Levees have been built and large pumping plants of 34-inch to 48-inch belted centrifugal pumps having a capacity of from 10,000 to 40,000 gallons per minute have been installed in a number of places.

"About 2,000,000 acres of the land in Louisiana jutting out into the Gulf of Mexico and forming the Mississippi Delta were covered a short time ago by cypress swamp. This land is rich alluvial soil of sedimentary origin, and Northern investors became interested in it, 1,200,000 acres passing into the hands of one concern alone. Reclamation work was carried on by ditching and pumping until it is now fertile and productive. The reclaimed land has an advantage over naturally drained land; for any degree of moisture can be obtained when desired in dry seasons by gates and dams.

"Low efficiency has prevented the general adoption of centrifugal pumps until recently, but with the latest design it is said that an efficiency as high as 86 per cent. has been reached."

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For cold storage work, the ammonia cylinder should have 7000 cubic inches displacement per minute per ton of refrigerating capacity. For can ice systems, the ammonia cylinder displacement per ton should be 12,000 cubic inches per minute per ton and for plate ice systems, the ammonia cylinder displacement should equal 20,000 cubic inches per minute per ton.

THE ACTION OF THE INJECTOR

A Clear Explanation of its Operation

By R. T. Strohm.

Despite the fact that it has been in use for almost half a century, the injector is still a subject of much misunderstanding and discussion. Numerous and varied have been the explanations of its action, and some of these have been so absurd in conception as to sound ridiculous. Let it be understood, then, that there is no mystery surrounding the action of the injector. Its operation is based on simple, natural laws which can readily be stated and understood. The mere fact that it has no moving parts need cause no confusion.

In Fig. 1, suppose that the tube *a* is connected with the steam space of a boiler, so that the steam, under pressure, is

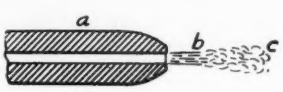

Fig. 1

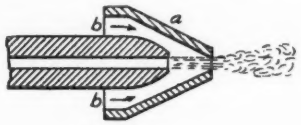

Fig. 2

free to escape through the tube. It will emerge in the form of a jet, as shown, moving at a great speed. Just beyond the end of the tube, as at *b*, the jet of escaping steam has a slightly conical form, while at a still greater distance, as at *c*, the jet expands and is broken up by the resistance of the surrounding atmosphere.

A tube like that shown in Fig. 1 is usually called a nozzle. When steam from a boiler flows through a nozzle of this kind, and escapes into the air, the velocity of the steam outside the nozzle may be from 1500 to 3000 feet per second, depending on the boiler pressure. This issuing steam has weight, and to give it such a high velocity requires that work be done upon it, just as it requires work on the part of a horse to move the weight on a truck. Now, work is produced by heat energy. Therefore, since the column of steam has had work done upon it in order to give it this high velocity, it is necessary to look for a source of the heat which is transformed into work.

This source of heat is in the steam itself. When the steam leaves the boiler it has a high pressure and temperature, and when it issues from the nozzle its pressure and temperature are both much lower. Evidently, the steam loses heat in its passage. But this heat is not lost by radiation from the pipe and nozzle. It is changed into work, which work, expended upon the steam, makes it move faster, so that while the steam in the boiler has practically no velocity, at the end of the nozzle it has a very high velocity.

But heat cannot be taken away from ordinary steam without causing some steam to condense into water. Consequently the steam that emerges from the nozzle is not dry steam, but contains moisture in the shape of very fine drops. Under different boiler pressures, this moisture may amount to from 10 to 20 per cent. of the weight of the steam.

Hence, as the steam passes through the nozzle, three things take place: (1) The pressure and the temperature both decrease. (2) The velocity of flow increases enormously. (3) The steam condenses to a greater or less extent. Then, for every pound of steam that passes through the nozzle, there is found to be a mixture of about .8 or .9 pounds of steam and from .1 to .2 pounds of water, at the mouth of the nozzle.

Now, suppose that the nozzle of Fig. 1 is so placed as to discharge through a cone-shaped ring, as in Fig. 2. The small end of the cone *a* is of such size that the expanded jet of steam had done, at first. But this jet of water, on account of of the steam jet when the latter is turned on will be carried along and forced through the cone by the moving jet. Other air will then rush in at *b, b* and, meeting the jet, will be drawn along with it in the direction of the small end of the cone. The continued friction of the steam with the air inside the cone will then set up a continuous current flowing through the cone in the direction indicated by the arrows. The mingling of the air and steam will cause still more of the steam to condense, while the velocity of the steam jet will decrease somewhat, owing to the fact that a part of its energy is used in giving velocity to the air.

Instead of a simple cone, open at both ends, let the device in Fig. 2 be changed to that shown in Fig. 3. In the latter figure the nozzle *a* is inserted through the back wall of the cone *b* which is closed at the large end with the exception of the opening *c*. The action does not differ in any way from the action of the device in Fig. 2. The air is driven and drawn out of the closed cone by the jet, causing a partial vacuum inside it, and to fill the space thus voided, air rushes in at *c*, and a continuous current is established, entering at *c* and emerging at the small end of the cone.

The devices shown in Fig. 2 and 3 will be recognized by many engineers as being the typical forms of various boiler room appliances, such as tube cleaners, soot suckers and blowers for producing draft, all of which depend on the production of a rapid current by the escape of steam through one or more openings.

It has just been shown that the flow of air upward through the pipe *c*, Fig. 3, is due to the fact that the pressure inside the

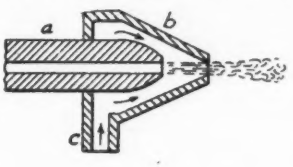

Fig. 3

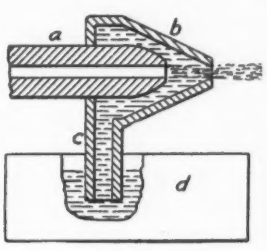

Fig. 4

cone *b* is reduced somewhat below that of the atmosphere. Suppose, then, that the pipe *c* is lengthened, and that its lower end is placed beneath the surface of the water contained in a tank, according to the arrangement shown in Fig. 4.

When the steam is turned on, it forms a partial vacuum in the cone *b*, as already explained. But air cannot rush in to

fill the space thus left vacant, since the pipe *c* is submerged in the tank *d*. However, the pressure of the atmosphere acts just as before, and it forces water from the tank up into the cone surrounding the nozzle *a*, completely filling that portion of the space not already occupied by the jet of moist steam. This action, of course, brings the water and the steam into contact, which can have but one result. The steam is condensed by the cool water, and the heat thus set free is taken up by the water. That is, the steam is cooled and the water is heated, the latter simply absorbing the heat that the steam gives up.

But the steam jet, just before it is condensed, is moving at a velocity of perhaps 2000 feet per second. Therefore, if this steam could be changed to water without any other action, the water thus resulting would have the same high velocity. However, this is not the case. Besides being condensed, the jet mingles with the water that is forced up from the tank. Consequently, owing to the resistance thus offered, the velocity of the condensed jet is very greatly reduced.

Instead of a jet of steam, there is now a jet of water particles moving toward the small end of the cone. This jet is surrounded by the water inside the cone. As a result, the friction between the jet and the water causes the latter to be drawn along, at an increasing speed, toward the outlet, the jet

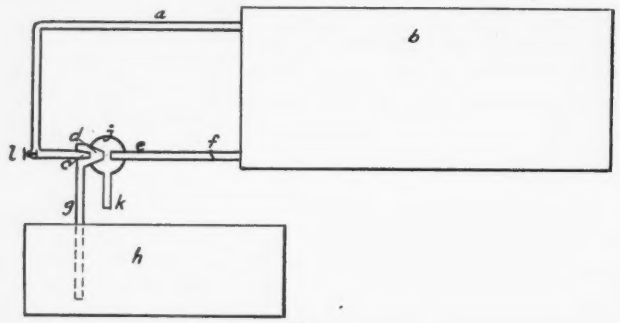

Fig. 5

meanwhile decreasing in velocity. At the mouth of the cone the mingled jet emerges, now an almost solid column of water which, though it has not the velocity of the original steam jet, is nevertheless moving at a fairly rapid rate, say 400 to 500 feet per second.

The condensation of the steam inside the cone produces another important effect. When a volume of steam condenses to water, the space occupied by the water is only about $^1/_{1000}$ as great as that originally occupied by the steam. Hence, in condensing in the cone, a partial vacuum is formed, to fill which the water of the tank *d* is forced up into the cone. As the condensation in the cone is continuous, the flow of water up through *c* is likewise continuous, and a steady stream is delivered at the mouth of the cone.

This issuing stream is not a solid column of water. It is rather a mingled spray, composed of water and vapor, the greater part, however, being water. Now, such a jet, moving at a velocity of several hundred feet a second, has considerable energy stored in it. And if the jet be allowed to impinge against a flat surface, it will exert a pressure upon that surface. For example, if the velocity of the jet is 400 feet per second and the weight of the mixture of water and vapor is 50 pounds per cubic foot, the pressure exerted by such a jet impinging upon a stationary flat surface will be several hundred pounds per square inch. A pressure like this is capable of overcoming considerable resistance.

Suppose, now, that the apparatus shown in Fig. 4 is attached to a steam boiler in the manner shown in Fig. 5. A pipe *a* leads from the steam space of the boiler *b* to the nozzle *c* inside the cone *d*. Just beyond the edge of the cone is another pipe *e*, containing a swing check-valve *f*, by which the water in the boiler is prevented from running out. A pipe *g* connects the cone *d* with a tank of water *h*, and a chamber *j* having an outlet *k* surrounds the mouth of the cone and the end of the pipe *e*. A valve *l* controls the flow of steam through the pipe *a*. This apparatus contains the elements of the steam injector as commonly built. The action is precisely like that of the cone, as already described in connection with Fig. 4.

When the valve *l* is opened, steam issues from the nozzle *c*, escapes through the mouth of the cone *d*, and leaps across the narrow opening into the pipe *e*. Here, however, it meets the closed check-valve *f*, which it cannot lift, owing to its slight pressure. Consequently, as soon as the steam fills the pipe *c* it is forced out into the chamber *j*, whence it escapes through the overflow *k* to the atmosphere.

But the rush of steam from the nozzle forms a vacuum inside the cone, and water is forced up into the cone, where it mingles with the steam, is heated and condenses the steam. The combined current, on leaving the mouth of the cone at a high velocity, leaps across the gap into the pipe *e*, just as the steam has done, at first. But this jet of water, on account of its weight and velocity, possesses much greater energy than the steam jet. Hence, when the pipe *e* is filled up to the check-valve, the water that continues to come from the cone raises the pressure to a high degree, and this pressure, being so much greater than that in the boiler, lifts the check-valve and the water passes through into the boiler. As soon as the check-valve is lifted, the escape of vapor or water at *k* ceases, and to prevent air being drawn in at *k* on account of the vacuum formed in *j* by the jet rushing across from *d* to *e*, another check-valve, opening outward, is placed in the outlet pipe *k*.

This, then, is the action of the injector. The steam, escaping at a very high velocity, gives up much of that velocity to the water, and the pressure of the swiftly-moving column of water is sufficiently great to overcome the boiler pressure, which it does.

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Air Reheaters for Compressed Air.

Atmospheric air is never perfectly dry and contains a varying amount of moisture or vapor, depending upon barometric and temperature conditions. When the mixture of air and vapor approaches the saturation point, a compressed air system which is working the air expansively will have to eliminate the excess of moisture, or heat the air, to prevent freezing and choking of the exhaust port. Various methods have been used for separating the vapor and air before admission to the air engine but the most practical and economical method is to heat the air close to the point of admission to the motor. By heating a given quantity of air it expands under constant pressure in direct proportion to the absolute temperature, so that a given quantity will do more work hot than when cold; which means a reduction in compressor capacity when using a reheater.

HYDRO-ELECTRIC POWER IN CANADA

By Frank C. Perkins.

There is probably no section of America where the development of hydro-electric power is receiving such attention at the present time as in the Dominion of Canada. Power plants are being established throughout that country in many of the provinces, not only by power companies and railway corporations, but also by municipalities, the latter in one instance considering the proposition of combining and establishing a Niagara Power Station for supplying the cities of the province of Ontario with current for light and power, not only for municipal service but also for distribution to the inhabitants.

The accompanying illustration, Fig. 1, shows the interior of the hydro-electric plant at La Chaudiere, Quebec, the unit in the foreground having a capacity of 1000 kilowatts, with its exciter belted to the shaft of the turbine and generator. This machine is of the Bullock water wheel type of alternator, constructed by the Allis-Chalmers Company, of Milwaukee, Wisconsin. In the background will be noted two smaller machines also direct-connected to hydraulic turbines.

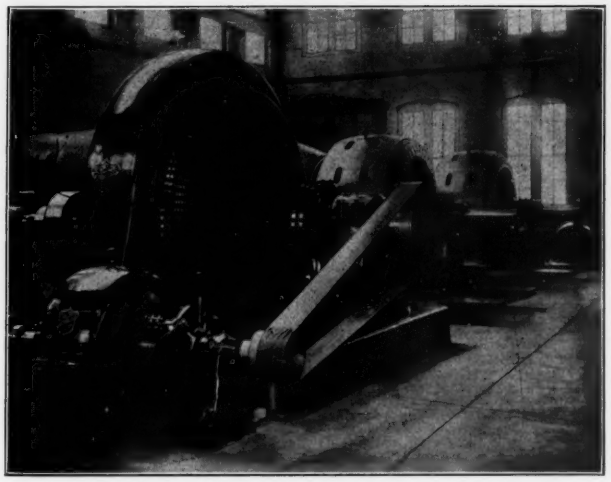

Fig 1.—Canadian Hydro-Electric Plant at La Chaudiere, Quebec

The Hydro-electric Station of the Town of Orillia, Ontario, Can., shown in Fig. 2, is of particular interest on account of the low price of power offered to manufacturers who will establish a plant in that town. Advertisements have been placed in Canadian papers by the Secretary of the Board of Trade of Orillia, offering 24 hour power in lots of one horse power or 1000 horse power at $16 per year per horse power. The accompanying view shows the power plant at Ragged Rapids on the Severn River, installed by this town for municipal lighting and power purposes. The current is used for lighting stores and residences, as well as for pumping water and for manufacturing purposes. The original plant was equipped with turbines and generators of 800 horse power capacity but the equipment has been supplemented by other machines until it has a present capacity of 1600 horse power, with provisions made for still further increasing the output.

This hydro-electric station is an alternating-current one, the current being generated at a frequency of 66 cycles and transmitted at a pressure of 22,000 volts. The plant is located 19 miles from Orillia, on Ragged Rapids, and originally cost $100,000, but has been increased in size with additional expenditures which will make the total cost about $300,000.

The current is generated at 1000 volts pressure by two ma-

Fig. 2.—Orillia Power Transmission Plant on the Severn River

chines of 300 kilowatts each, and one machine of 600 kilowatts capacity, the former being driven by single wheels of 600 horse power each and the latter by a pair of 40-inch water wheels, in one case, of 1000 horse power output. The current is raised in pressure to 22,000 volts by 8 transformers of 150 kilowatts each, and, after transmission to Orillia, is distributed from the substation at 2000 volts. From the income of the plant the town has been able to do its street arc lighting without expense, and it is expected that when fully developed the plant will render a fair income towards reducing

Fig. 3.—Power House of the Shawinigan Falls Alumimium Co.

the taxes, as well as supply lighting and power at remarkably low rates to the citizens and manufacturers who locate there.

The Shawinigan Falls power plant, which has been described in this paper, contains 3750 kilowatt Westinghouse alternators and horizontal turbines. This plant is now supplying current for the operation of the Montreal Electric Street Railway, and also for the Montreal Light, Heat and Power Co., the trans-

mission lines being about 85 miles in length. It has been stated by engineers of the Hydro-electric Commission of the Province of Ontario that power is delivered at this distance at $15 per horse power for 24-hour service under contract to the distributing companies.

The accompanying illustration, Fig. 3, shows the interior of the Aluminum Company's power station at the Shawinigan Falls power development, the two large turbine units being directly coupled to two 1000 kilowatt continuous-current machines, one at each end of each shaft of the water wheels. Five of these water wheels are supplied with water from one penstock, an additional penstock providing a total of 10,000 horse power.

The Hamilton Electric Light and Cataract Power Co., Ltd., is supplied with current from the St. Catherine's Hyro-electric

Fig. 4.—Canadian Hydro-Electric Station at St. Catherine, Ontario

Power Plant, shown in Fig. 4, also from a station at Decew Falls, at the Welland Canal Power Development. There are four horizontal shaft turbine wheels in the latter plant. These are double runner and double discharge turbines operating at a speed of 286 revolutions per minute with a capacity of 7100 horse power. There are also two Italian turbines of 3300 horse power each.

Capacity of Ammonia Compressors.

The refrigerating capacity of a compressor depends upon the number of pounds of gas it will handle in a given unit of time. The weight of ammonia gas handled depends upon the efficiency of the compressor and upon the suction pressure, or the pressure at which the gas is delivered into the compressor.

Since the weight of ammonia gas varies approximately as the absolute pressure, it follows that the refrigerating capacity of a compressor varies with the absolute suction or back pressure; thus, a compressor working under a suction pressure of 30 pounds gauge pressure will have approximately 50 per cent. greater capacity than one working under 15 pounds gauge pressure.

To obtain the net refrigerating effect of a compressor, it is therefore necessary to determine 1st, the suction or back pressure; 2d, the temperature at which the ammonia enters the refrigerating coils; 3d, the percentage of allowance to cover unavoidable losses.

In the operation of a refrigerating plant it has been found that the following conditions represent a fairly average practice:

Back or suction pressure 15.67 pounds above atmosphere (at which pressure ammonia evaporates at zero Fahr.), condensing water at 60 degrees Fahr. which gives ammonia liquid a temperature of 65 degrees Fahr.; under these conditions it requires the handling of about 7200 cubic inches of gas per minute to produce the effect equal to the melting of one ton of ice per 24 hours. This allows about 15 per cent. for unavoidable losses.

Before removing the manhole cover from a boiler, care should be taken to find out if all the water is drained out of the boiler and the safety-valve should be opened to insure atmospheric pressure within the boiler.

Examination Questions for Steam Engineers

An Honorary Certificate Should be Granted to Engineers Having Superior Qualifications

By Chas. J. Mason.

I have read with considerable interest the letters of E. S. H. and S. J. S. in the June issue of The Practical Engineer, pages 18 and 19, on the subject of examination questions. Both writers are right when the subject is viewed from their respective viewpoints and it would be a very difficult matter to so arrange an examination that every one concerned would be satisfied.

It appears to me that one possible way out of the difficulty would be to have, in addition to the regular grades, an extra or honorary examination for persons who have particular and superior qualifications and wish to be recognized in an official manner for the possession of such qualifications. The possession of an extra or honorary grade of certificate would be of real value—commercially and otherwise—to the possessor, without at all decreasing the value of the usual first-class certificate, which certifies that the holder of such certificate is a capable and trustworthy person to take charge of and operate any steam plant.

The man with a better education, and because of such, will be able to take an examination for the extra grade, may not be able to do any better with any given steam plant than his less fortunate brother-engineer, who, we will say, holds an ordinary first-class certificate; but when it comes to making a choice between the two, the employer may choose either, because the man with the first-class license can legally be placed in charge if the employer cares to engage him. Should the employer choose the man with the extra certificate, because of his superior qualifications, and pay him accordingly, the other man could not have any reasonable excuse for dissatisfaction on legal grounds—he stands equal to his better educated brother.

The foregoing plan would, I think, be better than the present plan for the three chief parties concerned—the employer, because of his choice of two grades of men, from the ranks of which any and all kinds of power plants may be served in any and all respects. For instance, some employers may want a chief engineer for their plants who will be required to occupy an office desk all day, dive and dig into figures, plan installations, make reports, look after those fine points in power plant engineering which require rare ability and such like; while, on the other hand, some employers want and require chief engineers who can keep their plants in operation and correctly at that; men who have mechanical and executive ability; men who have sufficient education to safely and economically operate any kind of power plant, but who are not able to answer questions of design, construction of theoretical indicator diagrams, academical questions relating to the *profession* of steam engineering rather than to the other branch—the *trade* of steam engineering.

The system of granting extra or honorary certificates to operating engineers was in vogue in Brooklyn, N. Y., for several years before the consolidation of the various boroughs of Greater New York. So far as I have heard and from my own personal observation, the system was a success and little if any dissatisfaction existed among the engineers in that city. Since the consolidation of Brooklyn and all the other boroughs into Greater New York, the extra examination became extinct, because the New York examining bureau took charge of the Brooklyn office also, and as New York did not have any grade higher than that of first-class, the Brooklyn engineers had to conform to the same rules.

The different grades of licenses in Brooklyn before the consolidation were designated by different colored seals. The grades were four in number:

(1) Extra First or Honorary, designated by gold seal.
(2) First-class, designated by a red seal.
(3) Second-class, designated by a blue seal.
(4) Third-class, designated by a green seal.

The holders of a first-class, red seal certificate, were permitted to take charge of *any* plant in the city. Some of the best steam engineers on the continent of North America held positions in Brooklyn under a red seal certificate; many of these men could have obtained a gold certificate had they so desired, but for reasons which were satisfactory to themselves they never sought the higher honors. Nor were they aggrieved at or jealous of those whose ambition was to secure the extra grade certificate. Those who possessed extra qualifications had the privilege of coming to the front and obtaining the honors through an examination. It served as a stimulus to the engineers who desired to get as high in the scale as possible, even though they might not always get the best positions.

The same system exists in Great Britain, in the mercantile marine, and never yet have I heard a single complaint with regard to it. Under this system, the man who *has* the educational qualifications, or who can acquire them, may make himself heard and known, so that *he* has nothing to find fault with. The man of mechanical training, pure and simple, who has neither the extra qualifications nor the ability to acquire them, in order to become a professional engineer, as well as a trade engineer, can show his fitness to safely operate a steam plant and receive a first-class certificate. With some employers he would be chosen in preference to the other fellow, and his certificate would enable him to accept the position. The honors enjoyed by the other fellow must be foregone by this man, so that he, too, has nothing to be dissatisfied with, except, possibly, himself.

As stated, I think the above plan would be an advantage which would be felt by all concerned.

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Air Receivers.

An air receiver serves the purpose of an air reservoir and corrects the pulsating effect of an air compressor. The larger the receiver or storage space between the compressor and the machine utilizing the air, the less marked will be the fluctuations in pressure.

HOW TO MAKE A SMALL ELECTRIC PLANT PAY

At the recent meeting of the N. E. L. A., Mr. D. F. Mager presented a paper with the above title, describing the methods adopted to transform into a dividend earner, an electrical plant operating in a town of 5000 population, that had previously been a losing investment. "It has been proven," he said, "that an entirely modern equipment is not essential for the financial success of an electric plant, and a wise manager of a small plant will hesitate before he consigns to the scrap heap equipment that he might, by overhauling and judicious arrangement of same, be able to operate at a net efficiency equal to the most modern equipment, besides saving for his company the amount required for new equipment and increased fixed charges that must necessarily follow such an expenditure. On the other hand, if he finds that his requirements and conditions call for an entirely new installation, he should not hesitate to make it, provided he can get the funds to do so—which is often difficult in a small plant.

"The boiler room is usually the most neglected part of a small plant equipment. Uncovered pipes, leaky valves and joints, improper boiler setting, careless firing and injudicious selection of fuel, are a few of the dividend-consuming devices common to small plants. It is well to have as few different sizes of valves, fittings, etc., as possible in the piping equipments. By making the nipples and short pieces of pipe of some uniform length, repairs will be simplified and many a shut-down be prevented, and a much smaller stock of fittings will provide for emergencies.

"Boilers should be inspected at regular intervals and kept free from scale. Scale in boilers is often the cause of enormous waste of fuel. Every steam plant should have recording thermometers installed in the feed-water lines to boilers. The average engineer in the small plant does not realize the necessity of heating boiler feed water to, at least, 200 degrees.

"Many central-station managers would have a rude awakening if they would take the trouble to install recording instruments. Recording voltmeters, as well as thermometers, will provide a healthy incentive for men to attend to their duties, and will also provide a means by which that mystery of voltage variation, which has given so much trouble at various times, may be solved. It is well known that one of the chief difficulties in small plants is to have competent help available when accidents or other trouble occurs, which is generally during the time of the heaviest loads. This has been provided for by dividing the power-house force into three watches, with the understanding that they are to work ten hours per day. This provides double force on duty two hours each day to make all repairs and tide over the peak-load period.

"Engines should be indicated regularly, and valves adjusted for the most economical steam consumption. Tests of water and fuel consumption should be made at stated periods. A log book should be kept, showing records of the hourly readings of the various instruments. Daily readings should be made of the switchboard wattmeters. No plant is too small for those instruments. If a plant cannot afford load-curve drawing instruments, the engineer or switchboard attendant should plot the daily load from the ammeter readings on sheets. The curve thus drawn will bring out plainly the hollow place in the load line that must be filled before one can corral that dividend-earning germ which all are striving to cultivate with more or less success.

"The distributing system of a small plant is very often the source of considerable waste. The annual losses from poor line construction, inefficient transformers and badly designed feeder systems, would go a long way toward paying dividends. The line and transformer losses on the above-mentioned plant at present are only 60 per cent. of what they were five years ago, when the income was only 25 per cent. of the present earnings. Thirty transformers were scrapped and the entire lot replaced with four large ones, using three-wire secondary network with banked transformers to take care of this large increase in business.

"The first duty of every manager is to provide for reliable and continuous service. He must furnish 'the goods.' Excuses won't go with the up-to-date American citizen. His next duty is to his company. He must see that it receives an equitable return for money invested by it to provide the equipment to supply this service. Before he can do this, he must first know, beyond question, what constitutes the various costs that go to make up the entire operating expenses of the plant. He must be able to make a monthly comparison of his various costs, for it is only by this means that he will be able to keep a check on his operating expenses. By studying carefully all the facts and factors that constitute his costs, the manager will be able to steer clear of the folly of taking unprofitable business."

Mr. Mager then goes on to state that in towns of less than 10,000 population, the manager must be his own solicitor for getting new business. He must keep posted regarding all new apparatus and should read not only the reading matter but the advertisements of the trade publications in his line.

One of the most desirable classes of customers is the small refrigerating plant, especially in connection with brine cold-storage tanks. Arrangements can be made with this class of customers to shut down their motor during peak loads. The cost of this class of power would be only the net additional cost of fuel and proportion of your general expense, as it does not increase the peak load on the station. A careful analysis of costs will work wonders toward helping the manager of small plants in building up that hollow of low business in daytime.

Besides depending upon advertising to obtain new business, there must be good and reliable service as a foundation to work on. The service must be continuous and free from interruption. Voltage must be steady and customers' installations must be looked after. He concludes his paper by showing the necessity of putting a plant equipment in the best possible condition before it can be hoped to get the operating cost as low as is consistent with first-class service.

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For cold storage work, the number of cubic feet to be cooled multiplied by 40 equals the number of British Thermal Units required, if the insulation is good. The number of British Thermal Units so calculated, divided by 284,000, equals the capacity of machine required, in tons per 24-hour run.

STEAM TURBINES GOVERNORS

DeLaval, Parsons and Curtis Method of Regulation

Owing to the fact that in a steam turbine the steam is made to give up its energy by impinging upon a series of buckets arranged upon the circumference of a rotor, the governing of the turbine is performed by controlling the amount of steam which impinges upon the turbine wheel.

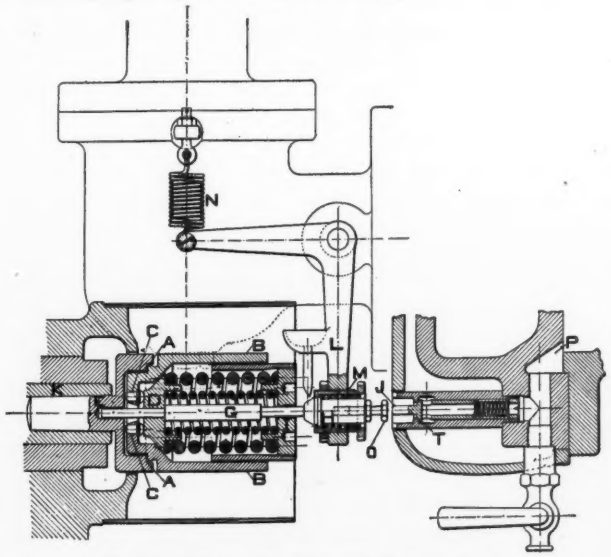


Fig. 1.—DeLaval Governor and Vacuum Valve

The De Laval steam turbine, which consists of a single set of vanes placed around the circumference of a comparatively narrow disc, has steam admitted to it through four nozzles set at ninety degrees to one another. This steam is ejected from these nozzles against curved vanes, imparting motion to them and rotating the shaft. The steam, on entering the small end of the nozzle, has a definite amount of static or pressure energy which is converted by expansion into kinetic energy.

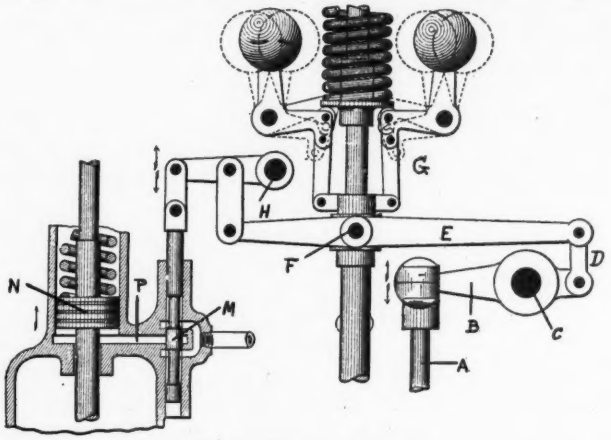


Fig. 2.—Parsons Governor

The governing of the De Laval turbine is accomplished by a fly-ball governor which acts upon the steam in the supply pipe, throttling it by means of a plunger, thus reducing the pressure. This reduces its energy and is usually the only mode of governing required for a non-condensing turbine. If run condensing, a vacuum governor must be used, because it has been found that the throttling governor will not control the speed within desirable limits when there are sudden changes of load.

With the high speed employed in De Laval turbines, a governor of small dimensions is used, shown in detail in Fig. 1. The two weights B are pivoted on knife edges A, with hardened pins C bearing on the spring slat D. E is the governor body, fitted in the end of the gear wheel shaft K, and has seats milled for the knife edges A. It is afterwards reduced in diameter to pass inside of the weights, and is in its outer end threaded for the adjusting nut I, by means of which the spring and eventually the speed of the turbine are adjusted. When the speed exceeds the normal, the weights, affected by the centrifugal force, spread apart and, pressing

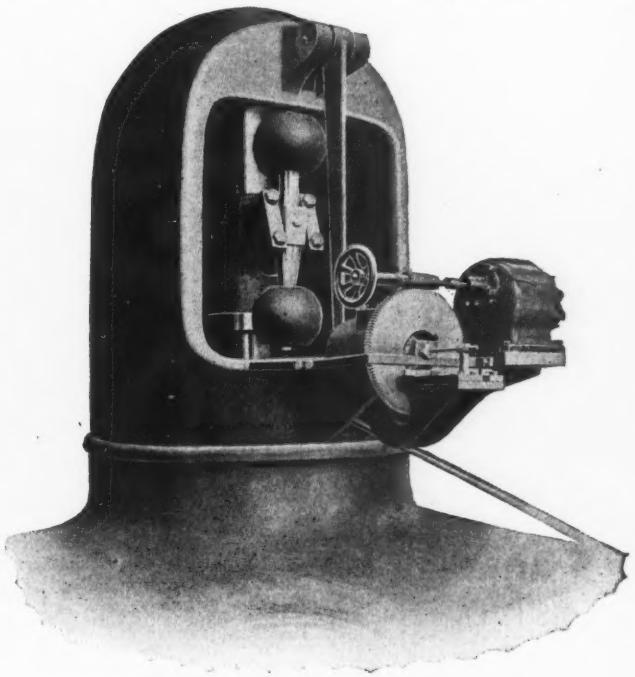


Fig. 3.—Governor for 5000 K. W. Curtis Turbine

on the spring seat D, push the governor pin G forward, cutting off part of the flow of steam.

The function of the vacuum valve is as follows: The governor pin G actuates the plunger H screwed into the bell-crank L, however, without moving the plunger relative to said crank. This is on account of the spring M being stiffer than the spring N, whose purpose is to keep the governor valve open and the plunger H in contact with the governor pin. When a large part of the load is suddenly thrown off, the governor opens, pushing the bell-crank in the direction of the vacuum valve T. This closes the governor valve, which is completely shut off when the bell-crank is pushed so far forward that the screw O barely touches the valve stem J. If

this is not sufficient to check the speed, the plunger H is pushed forward in the now stationary bell-crank and opens the vacuum valve. This allows the air to rush into the space P, where the turbine wheel revolves, effectually checking the speed.

The Parsons turbine is radically different from the De Laval, both in construction and principles of operation. Instead of a single wheel, it is made up of a large number of separate turbine wheels placed side by side on the same shaft, and the expansion of steam is continued through the entire series. In other words, the Parsons turbine makes use of successive expansions, each of comparatively small extent, by which the steam is given a series of decreasing pressures accompanied by corresponding increases in velocity.

The Parsons turbine is, therefore, regulated by a fly-ball governor which admits steam to the turbine in puffs. The duration of each puff is dependent upon the load under which the turbine is working. For a light load the puffs are very short, thus admitting little steam, while for a heavy load, the puffs are longer and consequently a greater steam volume is admitted. This peculiar form of admission is due to the governor arrangement, shown in Fig. 2. Regulation is accomplished by means of a constantly moving pilot valve controlled by the governor, both of which are operated by a worm gearing on the main shaft. The governor levers are mounted on knife edges to secure sensitiveness.

The operation of the governor is as follows: A is an eccentric rod, connected to an eccentric which derives its motion from the main shaft of the turbine. It is attached by a ball joint to the lever B, fulcrumed at C. The link D connects B with another lever E, whose fulcrum F may be shifted up or down by the governor G. The lever E, by means of other links and the fixed fulcrum H, is connected with the small relay valve M, whose motion from the mid-position will admit steam under the piston N, which is directly attached to the steam of the admission valve. It is evident that the reciprocating motion of the rod A, due to the eccentric, will be transmitted to the valve M, causing the port P to be opened in rapid succession. The result is that the piston N is alternately raised and lowered, thereby opening and closing the admission valve. As the governor increases or decreases its speed, the movable fulcrum F rises or falls and thus the relay valve M is given a movement sufficient to raise the admission valve and hold it open just the proper length of time. Since the valve M is in mid-position when full steam volume is being admitted, any increase of speed at once shuts off the steam.

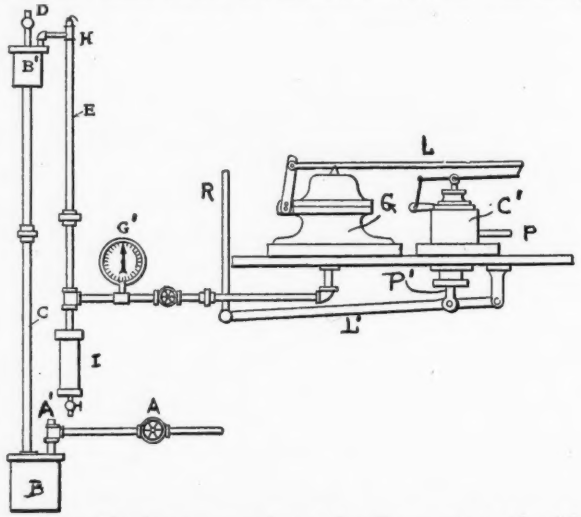
The Curtis turbine is different from either the De Laval or the Parsons turbine and yet resembles both. The steam is admitted into a series of nozzles in which a partial expansion takes place and from which the steam escapes into the first stage of the turbine. The first stage consists of three or four rows of moving buckets alternating with stationary vanes. After passing the first stage or group of wheels, the steam expands in a second series of nozzles which direct the flow of steam into the second stage or group of turbine wheels.

The speed of the Curtis turbine with variable loads is controlled by the automatic opening and closing of the original admission nozzle sections, the number of nozzle sections corresponding to the load always being kept in flow. A centrifugal governor, shown in Fig. 3, is attached to the top of the shaft and imparts motion to a lever which in turn operates the valve mechanism. There are a number of valves each communicating with a single nozzle section or in some cases two or more nozzle sections. These valves are connected to long pistons, by which the valve can be opened or closed by steam. The motion of each of these pistons is controlled by a small pilot valve which is worked by the governor mechanism. The movement of the governor mechanism moves the pilot valves successively and the main valves are opened and closed by the steam.

The Damper Regulator.

By Wm. Kavanagh.

Where a gauge is installed to record the variations of pressure, a sensitive damper regulator will be found necessary in order to maintain the pressure constant or approximately so. It is almost impossible for the fireman to hold a constant pressure, no matter how careful he may fire, and all variations of pressure will be traced upon the disc of the recording gauge. All modern steam plants are therefore equipped with one or more automatic damper regulators for the purpose of saving fuel as well as for maintaining the pressure constant.



In some plants, the use of the damper regulator is dispensed with, the fireman or engineer preferring to operate the dampers by hand on account of the difficulty encountered with such things as bursting diaphragms. A form of damper regulator which will, when erected and understood, prevent any trouble from bursting diaphragms and uncertain working or operation, is shown in the accompanying sketch.

This regulator is perfectly accurate and will control the pressure to within one pound variation and its operating diaphragm will last through a period ranging from five to ten years. Steam to operate diaphragm G is taken from the boiler through the valve A. The steam will now flow into pot B, in which a certain amount of mercury is placed, the mercury being deposited in B through the plug A'. The pipe C extends almost to the bottom of B, as shown by the dotted lines, and at its upper end connects into the bottom of B'. The pipe E is connected from the pot B' to the mercury catcher pot I and the operating diaphragm G is connected to the pipe E as shown.

Now the steam entering the pot B forces the mercury up the pipe C and the vertical distance between the pots B and B' determines the resistance the column of mercury will exert

against the entering steam, hence to lessen the pressure on the operating diaphragm G, all that is necessary is to lessen the vertical distance between B and B'. After the pot B is filled or partially filled with mercury, the system is then charged with water through the plug H. Vent D should be open during this operation but must be closed when sufficient water to fill the system has been poured in.

If water alone was used to resist the entering steam, the pressure on the diaphragm would equal or almost equal the boiler pressure, because the column of water in pipe E would balance the resistance of the water in pipe C and for this reason the system cannot be filled with mercury. It can be seen that if the vertical distance between B and B' is say 30 feet, and we carry 200 pounds pressure on the boilers, the operating diaphragm will be subjected to a pressure of about 33 pounds per square inch. Under this pressure, the diaphragm should last for an indefinite period and when this system is employed to protect the diaphragms, all trouble from burst diaphragms is eliminated.

The gauge G' is connected on the diaphragm pressure pipe as shown, and it will be found an excellent indicator of trouble. Should the diagram on connections leak for any reason, the pressure will rise and be indicated on the gauge and should the pressure rise above that which can be approximately calculated trouble may be looked for. The mercury catcher pot I is connected as shown, for the reason that should the diaphragm burst, the mercury would be shot into pot B' and should any of it be discharged into pipe E, it would fall into I, where it can be drawn off through the cock, as shown. The gauge G' can be located in some convenient place where the indicated pressure can be noted from time to time and any use in pressure over the usual amount will be sufficient cause for an investigation of the regulator and its connections.

The operation of the regulator is as follows: The diaphragm G operates the lever L, which lever is connected to the water valve lever L'. The water entering cylinder C' through the pipe P actuates the piston P' which piston raises or lowers the lever L', thus opening or closing the damper through the medium of the rod R.

CHANGES IN STEAM TURBINE DESIGN.

Defects Shown in Practice Remedied.

At the June meeting of the National Electric Light Association, the committee appointed to investigate the present status of the steam turbine, handed in their report of the changes and developments which have been going on during the past year.

In the Curtis turbine, mechanical control of the valves has been adopted in place of electrical control for all sizes. Bucket speeds have been increased from a speed of 325 and 350 feet a second up to 450 and 460 feet. Upon the question of whether water or oil was better for step bearings, it was thought that water was the most desirable, but it requires care to keep it free from grit. With water, a wood lined sleeve is recommended for the step bearing. Clearance between the buckets and guides has been increased to nearly double its former value. Difficulty has been experienced in keeping the casing tight which affects the vacuum, which defect can be helped by applying a coat of hot wax to fill crevices.

In the Westinghouse-Parsons turbine the lacing between blades has been changed from a flat form to a section like an apostrophe, the thin edge being bent over between blades, insuring uniform spacing and a tight joint. Double flow turbines are being used, in which part of the steam passes through the low stage of the turbine in opposite direction along the shaft. The first stage consists of an impulse wheel with two sets of buckets, steam being admitted through three nozzles, two arranged at the top and one at the bottom of the casing. The steam after leaving the impulse wheel passes on to a series of Parsons blading. After passing through a second stage, assuming that the impulse wheel is the first stage, a part of the steam continues in the same direction through the blading, the balance being carried through openings in the cylinder to which the blades are attached to the opposite end to another set of Parsons blading and in this way balancing the thrust. The advantages claimed for this machine are that it obviates the necessity of the use of large balancing pistons and it materially shortens the length and reduces the diameter, making the machine more compact; for these reasons the design particularly lends itself to the larger sizes.

All manufacturers are giving special attention to the design of the revolving-field generator. The General Electric Company has developed a design which apparently will overcome the difficulties due to changes in balance after the turbines are in operation. The new field structure that has been developed has been designed with distributed windings, with open spaces near the shaft, so that air can be received along the shaft and discharged by centrifugal force through the field laminations, and thus impelled through the armature laminations; the space at the ends being confined and arranged in such a manner that the air is positively forced through the inside outward. This air can be admitted at either end of the shaft, the intention being to close up the other end so that air is all taken from one end. The armature frame has no openings on its outer surface. The space between the laminations and frames at the end where the air is admitted is closed up. The air passes through the field and armature structures and then passes out at the end opposite that from which it has entered. Its flow is governed by a powerful centrifugal impulse, and it will consequently be possible to connect these machines by long pipes, if necessary, to points where cool air can be obtained, no blower being required in such pipes. As a rule, it will simply be desirable to extend such pipes to some low level in the station, where the air is naturally cooler than it is above turbines and steam pipes. These generators, having smooth rotors and no direct air communication outward, should be entirely free from noise. The total number of turbines of the Curtis type manufactured by the General Electric Company shipped or on order is 592 units, an aggregate of 580,325 kw. Of these, 385 units are of 500 kw. or larger.

The Westinghouse Company now has in operation 144 units having a total rating of 122,270 kw. It has shipped or on order 130 units, equivalent in capacity to 200,250 kw., making a total number of 274 units, an equivalent capacity of 322,-520 kw.

The Allis-Chalmers Company, which has recently entered the steam turbine field, has shipped or has under construction 17 turbines with a combined rating of 29,000 kw., the units varying in capacity from 500 to 5500 kw. The principal difference between this type of turbine and the standard Westinghouse-Parsons turbine is in the mechanical construction, balancing pistons, blading, the governing device and some other details.

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Practical Engineer

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The Metric System.

Just as regular as the June bug, or the melting of the winter snows, comes the agitation in reference to the adoption of the metric system in the United States and Great Britain, these being practically the only large countries that have not adopted the decimal system of weights and measures. Usually it is the advocates of the system who stir up the biggest fuss, but recently there has been some bold opposition against it.

The most earnest advocates for the adoption of the metric system have been found amongst professional and scientific men or those who are required to make long and extensive calculations. On the other hand, manufacturers and merchants have either been indifferent or have been opposed to the change.

The chief advantages of the metric system lie in the fact that the fundamental units are closely related which tends to facilitate computations and reduces the strain on the memory in making arithmetical calculations. This is a great benefit because the unit once learned can never be forgotten, while it is safe to say that a majority of persons never attempt to memorize our own system of weights or measures but keep hand books convenient for reference.

From the manufacturer's standpoint, the question of whether a detail part of a machine or engine should be measured in inches or centimeters, does not matter much, so long as everybody uses the same standard, and since he is using the foot-standard, he does not see any use of going to the expense of changing all his standards to suit the scientific men. In many large shops, not a single hole is drilled or a piece turned that is not measured by gauge which is numbered on a drawing. The workman goes ahead and does his work regardless of dimensions, in accordance with the gauge that is ordered by the drawing, with the result that all parts of an up-to-date machine are interchangeable and hundreds, and in some cases thousands, of these parts are shipped to every country on the face of the earth without any reference being made to the size of the piece, the gauge number being followed throughout. In very many cases, if the exact dimension of a gauge be found, it will probably not agree with any even figure in the metric or English system. Considering that machines may have as high as 10,000 parts or over, a locomotive having 13,000 separate parts, the jig or gauge habit would cause the metric system to die a natural death in machine shops if it were strictly insisted upon.

From the standpoint of the scientist, he thinks that this country can no longer announce to the world at large that because somebody once found that three barleycorns would measure an inch, that that should be taken as a standard, but instead we should take some standard such as the meter which is based upon the measurement of the meridian circle which passes through Paris, it being one ten-millionth part of the quadrant of this meridian. The scientist also claims that the standards used in the shops need not be changed, especially screw threads, since every nation in the world uses the United States standard screw thread.

In looking over the whole subject, it seems that before the metric system could be adopted in a popular way, the general public would have to be taught how to think in the metric system. It is not until we think of the length of an article in metres or gain some conception of the volume of a liter, that the system can become generally valuable.

The question, therefore, seems to be not so much the advantages of the metric system over the English system, but how can the metric system be introduced without endless confusion, without the loss of considerable money and without the gain of the popular contempt?

The Electric Lighting Problem.

The new illuminants which have sprung into being during the last two years have upset the placid minds of everyone using electric lights. Perhaps the most disturbed persons are the central station managers, for with the new illuminants have come greater ecenomy in the use of the electric current. This means that for the same amount of illumination, the income of many of these plants will be considerably reduced, providing the customers use the new forms of lamps. For the isolated plant it means a great boom, for it will require a less amount of energy for a given amount of illumination and hence a saving at the coal pile.

Within a few years, the 3.5 watt carbon filament lamp and the enclosed or open arc lamps were practically the only ones to select from, but now there are the 2.5 watt graphitized filament lamp, the 1.85 watt and 2.2 watt tantalum lamp, the one-watt Kuzel metallic filament lamp, the luminous arc lamps, the Nernst lamp, the Cooper-Hewitt mercury vapor lamp and the Moore vacuum tube lamp.

If the energy consumption of the new lamps were the only factor to deal with, the situation would at once clear and a new standard of lamp ecenomy could be adopted, but the situation is made very complex by the first cost of the lamps, the uncertain life of the lamps and their adaptability on different circuits. If the central station is furnishing free lamp renewals, they are met with the problem of either furnishing the new high efficiency lamp free or of making some kind of charge based upon the difference in cost of the lamps.

The new graphitized filament lamp saves 20 per cent. in energy for the same candle power and life or will give 25 per cent. more illumination for the same cost of energy and maintenance, the cost of the lamp being about 20 cents compared to 16 cents for the regular carbon filament lamp. The tantalum lamps save considerably more in energy but cost 75 cents per lamp and it is not yet adaptable to alternating current circuits. The Moore vacuum tube lamp gives a consumption of 1.5 watts per candle, but its principal use is for lighting large areas. It is claimed that about 70 per cent. of the energy is saved over the ordinary incandescent lamp and that the vapor in the tubes will last indefinitely. The principal objection to mercury vapor lamps is that the light is lacking in red rays, making the appearance of many colors quite confusing.

In the arc lighting field, the flaming arc lamps are creating quite as much stir, among which the "magnetite" lamps have the lead. In Portland, Ore., where these lamps have been installed for some time, the "magnetite" lamps use 320 watts per lamp in place of the usual 500 watt arc lamp. Besides the saving in current, it is claimed that the flaming arc lamps are better adapted for street illumination, since the origin of the light is larger than the crater of a carbon arc lamp and hence distributes it better. The principal objection to the "magnetite" lamps seems to be the increased cost of renewals, the "magnetite" sticks costing considerable more than carbon sticks, and for interior lighting, the production of yellow fumes and lack of steadiness are said to be two undesirable features.

Considering the unrest which is taking place in the lighting field and the many experiments which are being made along widely different lines, it is quite probable that a durable 2-watt incandescent lamp will soon be found to answer the requirements of all commercial circuits.

Engineering Progress in Canada.

It is said that the phrase: "The nineteenth century belonged to the United States, the twentieth century will belong to Canada," is rapidly spreading from the oratory of the Canadian public men into the convictions of the Canadian people. This is due to the remarkable progress made in the industrial and engineering development of the Dominion during the past few years.

The natural advantages which Canada possesses in the way of water power has led to the erection of many hydro-electric plants, several of which are described in another column of this issue, and which offer power so cheaply that they are attracting large power users to their locality. The erection of the new provinces of Saskatchewan and Alberta in the Northwest, which are exceedingly rich in agricultural and mineral possibilities, and the construction of several new transcontinental railroads have given impetus to a country whose valuable resources have been slumbering.

That our Canadian neighbors are making giant strides is shown from the increase in trade with the United States, the official figures showing that in 1895 our trade with them aggregated $89,429,000, while last year it totaled the large sum of $203,000,000, of which it is safe to say a large part was due to increase of machinery used in the erection of power plants and factories.

The vast mineral resources of Canada are also said to include extensive coal deposits, so that when the water powers are all utilized, there will be no lack of fuel to continue the industrial progress which is now going on. It will be well in the future to keep an eye on the Canadian engineers, who are making such progress, and while we may take exception to the statement that "the twentieth century will belong to Canada," there can be none if this were changed to read: "The twentieth century will belong to America."

Texas Leads in the Number of New Central Stations.

That the number of central electric power stations is continuing to increase is shown by the recent issue of the *Central Station List*, which shows a gain of 301 plants during the past six months, or 600 for the past year. The total central station plants now number 4839, of which 3732 are under private and corporate management and 1107 are municipal plants. Of the new plants erected in the first half of 1905-6, no fewer than 48 were in Texas, 21 in Pennsylvania, 18 in New York and 15 each in Ohio and in Michigan. It has been estimated that all these plants are worth approximately $700,000,000, the gross earnings aggregate $135,000,000 and the expenses of operation $94,500,000.

In a recent issue of a so-called engineering paper, an article appears on lubrication, in which friction is defined as negligence, ignorance, or bad judgment. According to this standard, we wonder what the definition of the coefficient of friction would be?

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

Examination Questions Answered. Method of Finding the Diameter of Cylinders, Initial, Terminal and Mean Effective Pressure of Compound Engine.

EDITOR THE PRACTICAL ENGINEER:

In the May issue, J. R., of Fall River, Mass., sends a list of questions that were given him by the examiner of engineers when he applied for a first-class license; he also states that he gave them to some men who had first-class licenses and they were not able to answer them. Now, I think J. R. makes a bad mistake in saying that the members of the N. A. S. E., to whom he gave the questions, could not answer them, as there are members in that association with first-class licenses that could have done any of those examples without much trouble.

If my memory serves me aright, when those questions were brought up, they started a discussion on what constitutes a 2000 horse power engine, one member claiming that he could take five or six different sizes of cylinders for a 2000 horse power engine; another member claimed that the questions were given for stickers, as the inspectors did not want to give J. R. a first-class license and if J. R. had done those examples, he would have to assume everything, such as the size of cylinders, length of stroke, revolutions per minute and mean effective pressure. Another member also claimed that the questions were not fair ones, as the inspector gave J. R. no constant to go by; that is, he should have been given some point to start from, such as the mean effective pressure, piston speed or revolutions, this member also claiming that it made no difference whether the engine was horizontal or vertical.

Another member showed how engine builders in putting in bids for a 500 cross-compound engine gave the sizes of six different engines for doing the same work, as follows:

A engine—20 x 38 x 40— 90 revolutions.
B engine—19 x 36 x 42—110 revolutions.
C engine—20 x 38 x 48— 80 revolutions.
D engine—20 x 36 x 48— 80 revolutions.
E engine—20 x 36 x 36—100 revolutions.
F engine—20 x 40 x 48— 80 revolutions.

The engine that was purchased was the 20 x 40 x 48 running at 80 revolutions. That engine today is doing 850 horse power and at times 900 horse power, gauge pressure at that load, being 135 pounds with 26 inches of vacuum at the condenser.

Now the question is, could those six questions stop a man from getting a first-class license? If my memory serves me aright, when I was examined, there were 52 or 54 questions to be answered and I am very sure that 9 out of every 10 were good practical questions and, of course, a few of them were catch questions, but that is always to be expected in an examination.

The following example worked out by a man who had to get down and dig to get his license will answer four of those questions of J. R. and card No. 2 on page 9 of the May issue of THE PRACTICAL ENGINEER will come pretty near answering the question in regard to ¼ late admission of steam:

To find the approximate diameter of the cylinders of a compound engine of 2000 horse power and the initial, terminal and mean effective pressure of each cylinder, economical boiler pressure, 140 pounds; piston speed 720 feet per minute; terminal pressure, 6 pounds; back pressure, 3 pounds; drop in pressure between boiler and throttle valve, 5 pounds.

Then, $140 - 5 = 135$ pounds initial pressure, $135 \div 6 = 22.5$, total number of expansions, and the expansion in each cylinder is equal to $\sqrt{22.5} = 4.74$. The terminal pressure in high-pressure cylinder is equal to $135 \div 4.74 = 28.48$ pounds absolute. Average mean effective pressure of the high-pressure cylinder is equal to (1 + hyperbolic log of 4.74) $28.48 = 72.79$ pounds absolute, and $73.79 - 28.48 = 44.31$ pounds, mean effective pressure of the high-pressure cylinder.

Average mean effective pressure of the low-pressure cylinder is equal to (1 + hyperbolic log of 4.74) $6 = 15.34$ pounds absolute or $15.34 - 3 = 12.34$ mean effective gauge pressure of low-pressure cylinder.

It is desirable to have the cylinders so proportioned that the work with the above conditions shall be divided, so that 1000 horse power will be performed in each cylinder. Then the area of the low-pressure cylinder can be found from the formula:

$$\frac{33{,}000 \times \text{H. P.}}{\text{Piston speed in ft.} \times \text{M. E. P.}}$$

Substituting

$$\frac{33{,}000 \times 1000}{720 \times 12.34} = 3714.2 \text{ square inches}$$

from which the diameter of the low-pressure cylinder is found to be 68.76 inches.

According to the same formula, the area of the high-pressure cylinder will equal

$$\frac{33{,}000 \times 1000}{720 \times 44.31} = 1034.37 \text{ square inches}$$

from which the diameter of the high-pressure cylinder is found to be 36.29 inches.

The size of the cylinders for a compound engine as per conditions stated above will be, 36 x 69 x 60 at 72 revolutions per minute. With 140 pounds absolute pressure, there will be 22.5 expansions in the engine or 4.74 expansions in each cylinder, exhausting into a condenser against 3 pounds back pressure or into a vacuum of $14.7 - 3 = 11.7 \times 2.036 = 23.82$ inches of vacuum.

The rule for finding the approximate horse power of a compound engine is as follows: Assume that the entire work is to be done and the expansion all takes place in the low-pressure cylinder; then 1 + hyperbolic log of the total number of expansions, multiplied by the terminal pressure in the low-pressure cylinder, will equal the average mean effective pressure due to the expansions; this product multiplied by the area of the low-pressure piston and by the piston speed in feet

per minute, and the whole divided by 33,000, will give the approximate horse power of the engine.

Fall River, Mass. M. H. H.

Faulty Cylinder Lining. Fish in Suction Pipes. Trouble with Frogs Remedied. Centrifugal Pumps for Lifting Quicksand.

EDITOR THE PRACTICAL ENGINEER:

The letter of C. W. D. in the April issue, about a faulty cylinder lining, recalls a somewhat similar experience of mine. A few years ago, I was called upon to locate the pound in a 7 x 4 x 10 duplex boiler feed pump and easily located the trouble in one water cylinder. Upon removing the cylinder head, nothing was to be seen out of place, so the valves were gone through and the balance of the pump looked over. However, when started, that cylinder still had the pound at both ends of the stroke. On removing the cylinder head a second time, the trouble was found to be with the cylinder liner, which in that make of pump is held in place against a shoulder in the middle of the cylinder by three or four cap screws, screwed through lugs on the end of the liner and backed out until they come up tight against the inner head of the cylinder. These screw heads had become so eaten up with rust as to allow a slight end play on the liner and this had gradually become worse, so that there was nearly an eighth of an inch play for the liner, and at every stroke the packing would pull the liner along until it brought up, making the slam we heard. What fooled us, in the first place, was the fact that we were looking for a loose piston and in order to examine that, we had stopped the pump on that end of the stroke, so the screws were hard up against the inner head when we took the outer head off, making it look all right. Fig. 1 will give an idea of the construction of this pump and where the trouble was found.

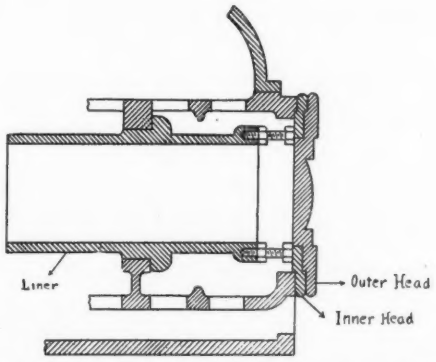


Fig. 1—Construction of Pump in which trouble was found

Your correspondent's experience with the fish in the suction pipe is an interesting one, although I should have predicted that a fish could not have lived long under those conditions. At one plant where I was employed we had an underwriter fire pump and while putting a pressure test on some lines of hose one day, I detected a churning noise in the water end, seemingly on the lower deck of valves. When the pump could be opened, I found several of the rubber valves badly cut and worn by fish bones and many quite large pieces of bone in the water chamber. The suction pipe on this pump was twelve inches and had no strainer, except the trash rack at the forebay, which was made of ½ x 1½-inch iron set edgeways at 1½-inch centres. How long the fish lived after reaching the suction pipe, I have no means of knowing.

At another plant we had a large fresh water reservoir supplied by wells and all the pump suctions ran to this reservoir. We had a great deal of trouble with frogs, which would get in there by the thousand, some dying and others going through the pumps and out into the plant, which used a great deal of water for manufacturing purposes. Someone told the manager that water snakes would eat up the frogs, so he had three put in the reservoir. Then we learned that not only did the frogs increase as fast as ever, but the snakes were drawn through the pumps and delivered into the plant, the first evidence of this being the failure of a valve to close, one day, and the discovery of the dead snake when it was taken down by the pipe fitter. As the way the frogs were finally eliminated may prove useful to some of your readers, I will describe the plan.

The location of the plant was in the Southern States, well inland. Nearly all the inland streams of this country are inhabited more or less thickly by a species of water birds, called grebes. There are several indistinct species allied with these grebes. They are relatively small birds, remarkable for their quickness in diving. They feed almost entirely on small fish and frogs.

We had noticed that a small piece of board placed in the reservoir would soon become covered with frogs, coming up for sun and air, and working along these lines, I made several small platforms of boards and anchored them in different parts of the reservoir. These immediately became covered with frogs of all sizes. Such a large congregation of frogs attracted the birds and in less than two weeks the only frogs left were some overgrown fellows, chiefly valuable for their hind legs, but too big for the birds. We left the rafts in place and the birds paid us daily visits whether or not they were rewarded by a frog dinner.

In reply to S. P. N., St. Louis, Mo., who desires a method for lifting quicksand, there is a special water packed centrifugal pump in the market for that kind of work, but, unfortunately, I have mislaid the address of the manufacturers. If the excavation he desires to make is a small one, he could probably rig a well driller's sand pump and use it to advantage. These may be purchased of any dealer in oil well supplies at a nominal price, or made at home, if desired. The home-made one would probably cost the more, however.

East Greenwich, R. I. L. L. ARNOLD.

Reason for Sticky Valves. Compressed Air for Injectors.

EDITOR THE PRACTICAL ENGINEER:

I am surprised that H. M. G. with his 35 years' experience with Corliss and Greene dashpots has not yet learned what in my experience is the principal cause of sticky steam valves with light loads and high pressures. The reasons he gives are all good ones, but they may cause valves to be sticky at any load or pressure. The real reason for the condition under the circumstances named is that the high pressure on the valves causes so much friction that it cannot be overcome by the slight vacuum formed by the very short lift of the piston of the dashpot.

The very simple remedy is to throttle the steam until the pressure is sufficiently reduced, when the valves will run all

right. H. M. G. might pump in gallons of oil without stopping the sticking under the conditions named. In the light of the above explanation, the invention of V. M. (June number) is shown to be superfluous.

While P. J., in the June number, speaks of the "partial vacuum formed in the mixing space," in asking his question: "What would prevent compressed air from being used instead of steam for forcing water to boilers?" it is still very clear that he does not understand the theory of the injector.

If his air pressure was higher than boiler pressure, he would perhaps get water into the boiler by its use, but with dire results to the vacuum in his condenser. Under the usual condition, viz., same pressure at injector as in boiler, there would simply be a balance of forces and no action at all when compressed air is used.

In an injector, steam is condensed by the water, thus forming a vacuum into which the water is forced by the pressure of the atmosphere. It is the momentum gained by the water flowing into the vacuum which overcomes the boiler pressure and friction of pipe and fittings.

Boston, Mass. H. E. F.

It is not Practical to Locate Leaky Pistons with an Indicator.

EDITOR THE PRACTICAL ENGINEER:

In the article written by Mr. Wm. Kavanagh in the May issue, there is a statement as follows: "The case of a leaky piston is shown in Fig. 5, the back pressure line showing a decided drop, as well as the expansion line." Now in Fig. 5, referred to, there is no evidence for reason to believe that there is a leaky piston. The same card could be produced from an engine with the piston leaky or not. There is nothing about the expansion line to show a leaky piston and the back pressure line shows very distinctly that the exhaust ports or passage is too small to allow the free escape of the exhaust, causing a rise in the back pressure line as the piston increases in speed up to mid-stroke when the piston is moving fastest, and a drop in the back pressure line as the piston reduces its speed.

It is not practical to locate leaky valves and pistons by means of the indicator, as a leak may be very serious and not show on an indicator diagram. To test for leaks, remove the indicator plugs or open the indicator cock on one end of the cylinder; place the engine on centre and turn on steam in the end opposite the open cock when a leak may be detected. A leak in the other end may be detected in the same manner. A better way is to remove the cylinder head and turn steam on opposite end and a leak may be easily found.

Princeton, Ind. C. B. RISLEY.

Result of a Careful Examination.

EDITOR THE PRACTICAL ENGINEER:

Owing to the increase of the demand for the article which is made where I am employed as engineer, my manager decided, after considerable figuring, to put in another boiler, of the same dimensions in every detail as those that are at present in service, they being of the return tubular type, 56" in diameter by 18' long, containing 34 4" tubes rolled and beaded at each end. The new boiler had been duly built according to furnished plans and specifications and in due time was placed in its proper position with the regulation pitch of 1" to the back head.

The front and settings were duly placed, and practically everything was in readiness to put water in it to steam up, when, as has always been customary with me, I made my regular examination of the boiler. I had carefully examined the inner butt straps to see that no "dutchman" had found its way in on a burned sheet corner, each diagonal brace was rapped thoroughly, and the overhead feed line connections were examined very closely. Everything seemed to be in good shape

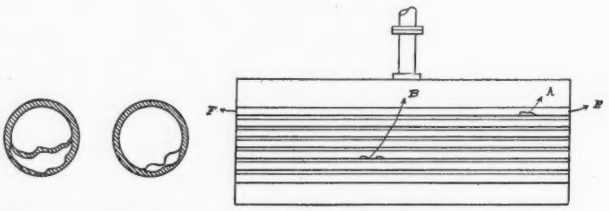


Fig. 1 Fig. 2 Fig. 3

and the erector had told me that the boiler had stood the test of 200 lbs. to the square inch, at the shop, so I was about to take it for granted, when it occurred to me to have a look at the internal portion of the tubes.

I called the fireman and had him get into the combustion chamber and beginning at the right hand side near E, as is shown in Fig. 1, in the accompanying sketch, I had him hold a torch immediately in front of each tube while I glanced through them from my position, as shown at F in Fig. 3. I had peered through three tubes when I told the fireman to wait until I knocked out that piece of dirt at A, as I supposed, when to my utter surprise I found it to be a part of the tube. We examined the rest of the tubes very carefully and found two blisters, as are shown at A and B. I immediately called in a boilermaker, had him take the two tubes out, wired the company that had furnished the boiler, and they immediately forwarded two new tubes, and stood all the expenses of the replacing of them, etc. Figures 1 and 2 are intended to represent the cross sections of the tubes where they were damaged, these pieces were cut off with a hack saw and forwarded to the builders of the boiler as proof of the fault. 'Twas a good thing I hadn't had any fire under that boiler or who knows what the decision of the builder might have been. So I think a little look around sometimes pays you many fold for the trouble, if you can call it such.

Depew, N. Y. C. W. D.

More About Examination Questions.

EDITOR THE PRACTICAL ENGINEER:

How can water be delivered to a boiler by a small Deane duplex boiler feed pump, placed beside the boiler, from a well 40 feet below the surface?

The above question was fired at me in an examination about one year ago, probably in the same room where J. R., of Fall River, Mass., was given his questions. I answered very truthfully that I did not know, at which the worthy examiner remarked with an air of deep disgust that it was a very simple matter and most engineers could do it. I have since put this question to a great many engineers of all license grades but I am still as wise as before.

As to whether J. R.'s questions are fair ones or not, there is no doubt in my mind but that they are entirely so. The law is intended to prevent boiler explosions and so provide for the greater safety of the public. The possible consequences of ignorance of such things are something frightful to contemplate and if J. R. will carefully consider the matter in this light, I think he will see it the same.

Providence, R. I. R. J.

Merits of the Metric System.

EDITOR THE PRACTICAL ENGINEER:

In view of the increased attention being given now to the subject of the Metric System of weights and measures, I think that a discussion of the subject in your columns would be of interest and profit to all.

The term "discussion" may not be quite advisable in this case as it implies arguments for and against the project, while the proposed metric system seems to me to have absolutely nothing against it, except that it is an innovation, which can hardly be called a fault.

The merits of the system are legion: its simplicity; its international character, being in use in over 40 civilized countries including nearly the whole of Europe (excepting the British Isles, a large part of S. America, the Philippines, Japan, New Zealand, etc., and the attitude of the scientific world towards the system, should commend it particularly to engineers, yet they seem to be among its chief opponents.

Their prime objection seems to be the difficulty of maintaining two separate standard of sizes in screws, threads, etc. This would have to be done for a time, certainly, but as Prof. McLennan, of Toronto University, in a lecture stated recently, the lathes in present use can be used for cutting taps, dies and threads to parts of a centimeter instead of parts of an inch by merely using two gear wheels of 50 and 127 teeth respectively, the ratio of a centimeter to an inch being .3937 to 1, or as 50 to 127.

The only unfortunate feature of the metric system seems to me to be difficulty of dividing the number ten. Unlike 8 or 12, it has few measures, but this could only be remedied by changing our numerical base, which is entirely impractical, as human beings always have had ten fingers and ten toes and are always likely to have, this being the probable origin of the 10 used in the metric system of computation.

There is much to be said in favor of the adoption of this system and perhaps against it, but the latter I leave for some other contributor.

Edmonton, Canada. F. H. S.

Questions Mr. Kelly's Advice about Compounding Dynamos.

EDITOR THE PRACTICAL ENGINEER:

In the May issue there is an article by A. C. Kelly, on operating compound dynamos, in which there are some things which are apt to be misleading. Mr. Kelly says: "After everything is ready to put the machines in parallel when one machine is taking the load, bring the other machine up to voltage and adjust it about two volts higher than the machine you are going to throw in parallel with." He then says that this is done so that it will not take its share of the load.

Now, I find that the machine which has the highest voltage takes the most of the load; so when I am putting two machines together, I always set the voltage a little lower on the machine that I am putting in and after it is in, I raise the voltage until it takes its share of the load.

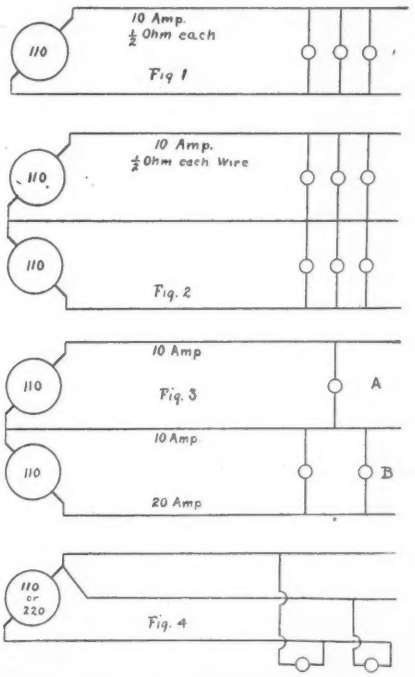
I would also like to know what Mr. Kelly means by increasing the field excitation to bring the machine to take its share of the load; for, if increasing the field excitation is the same as raising the voltage, the voltage was higher on No. 2 machine when he put it in; if not, I would like to know how Mr. Kelly increases the field excitation and brings up the voltage on the same machine at the same time with the same rheostat.

Rutherford, N. J. R. M.

Regarding the Three-Wire Generator.

EDITOR THE PRACTICAL ENGINEER:

The question of the operation of the three-wire generator having been brought up in your paper, I would like to say this: There is a 3-wire generator where I work and there are also two generators connected in series to the 3-wire circuit. The single 3-wire machine is used for power and is coupled on the line for day service; most of its power is used at 220 volts, but there are also three 110 volt motors used for crane service. When any one or all of these motors are in use, the 110 volt sides change voltage. Now, the machine can be regulated as a whole with the rheostat with regard to the 220 volts,



but there is no way that the man in charge can regulate the 110 volt circuit.

The 3-wire system has its peculiarities, which can be explained by taking a single circuit as shown. Each wire has a resistance of ½ Ohms and suppose 10 amperes are flowing through the circuit at 110 volts. Now we get a drop of 5 volts going and 5 volts returning, leaving $110 - 10 = 100$ volts effective at our work. Suppose we connect another similar circuit in series with this one, as shown in Fig. 2, using one wire at the middle. Now we get a drop of 5 volts going and 5 volts returning, leaving $220 - 10 = 210$, and that di-

vided by two, gives 105 volts; which are effective. Now suppose we put on another load as shown in Fig. 3. We lose 5 volts going out and as we cross the middle wire, we meet a voltage of $110 - 5 = 105$ volts; then the effective voltage at A is $220 - (5 + 105) = 110$ volts. Owing to the larger load, we lose 10 volts returning, then $105 - 10 = 95$ volts at B, or the sum of the voltages plus the losses $= 110 + 95 + 10 + 5 = 220$ volts at the dynamo.

I would respectively ask the correspondent how a single 3-wire generator can make this come up equal? Should the middle wire have been smaller than the others, as is usually done, the results would have been the worse for it. The middle wire ought to be as large as any of the others and if large, out of balance loads are to be carried, it should be twice as large. With two dynamos in series each can be regulated separately and the voltages kept equal on the line.

It seems to me that straight 110 or 220 volt machines are better connected up as shown in Fig. 4, making either two negative and one positive or one negative and two positive. If this is carried out throughout the system and should a fuse blow, only half the lights or motors would be disabled.

Groton, N. Y. M. E. Y.

Slide Valve Adjustment without Opening Steam Chest Cover.

EDITOR THE PRACTICAL ENGINEER:

These points are valuable for slide valve engines, where there is difficulty to get at the slide valve and adjust it.

To square the valve, place the piston at any point in the stroke. Then turn the eccentric until it is at the extreme of travel and make a mark on the valve stem, open the drip and turn the eccentric until steam appears at the drip and make a mark on the valve stem, then measure the distance between the two marks. Now revolve the eccentric until at the other extreme of travel and make a mark on the valve stem, open the drip at the end and open the steam valve a trifle, revolve the eccentric until the steam appears from the drip and make another mark on the stem and measure the distance between the two marks. Now compare the two travels. If the crank end is ½" and the head end is ⅜", you can split the difference from the eccentric rod, lengthening or shortening until the two travels are equal, then the valve is square.

To find the amount of lap and also to square the valve. Place the engine at the centre and bring the eccentric at right angles to it and make a mark on the valve stem, open the steam valve, turn the eccentric a little until steam appears from the drip, then make another mark on the valve stem and measure the distance between the marks. Now turn the engine over and place it at the other dead centre, turn the eccentric over again until it is at right angles to the crank, open the steam valve and make a mark on the valve stem, advance the eccentric a little until steam appears from the drip and make another mark on the valve stem. Now you will know how much lap you have on both ends according to the marks, and you can split the difference through the eccentric rod, lengthening or shortening.

To give lead, place the piston at the centre and if there is a direct rocker-arm, advance the eccentric 90 degrees ahead of the crank, and open your steam and drip valves and notice when the steam appears—fasten the eccentric there.

To find the point of cut-off, when the valve has been set correctly you can proceed as follows: Place the engine at the dead centre and make a mark on the guide, leave the drip open, and open the steam valve a trifle, revolve the engine over until steam ceases to come out from the drip, stop there and make a mark again on the guide. Measure the distance of the two marks. Suppose the distance is 12" and the stroke of the engine is 16", then the point of cut-off will be three-quarters.

Boston, Mass. VASIL MACKAY.

Slide Valves less likely to Prevent Accidents from Water in Cylinder.

EDITOR THE PRACTICAL ENGINEER:

It is worthy of note in connection with the South Boston, Mass., engine accident, described in the June issue, that the engines in question were of a make using piston valves throughout. The claim which has been made from time to time by engineers, that the piston valve does not offer any relief to the cylinder in case a dose of water comes in, seems to have been well founded in this particular case.

Of course, when a large body of water finds its way into an engine cylinder, either through the condenser or otherwise, a break usually is the result, whether the engine has piston, Corliss, flat or poppet valves, because no valve was ever designed, nor ever will be, that will relieve the cylinder in extreme cases and prevent a break; but practically speaking, it cannot be denied that the chances for a break are greater with an engine fitted with piston or Corliss valves, for instance, than there would be with an engine fitted with flat valves, for the reason that the flat valve, unless prevented by some form of pressure-balancing device, will leave its seat and thus relieve the cylinder to a certain extent. The Rollins and the Brown engine are pretty good examples of these.

E. Pepperell, Mass. J. A.

Water in Hollow Slash Bar.

EDITOR THE PRACTICAL ENGINEER:

I have just received my first number of your paper and find it very interesting. Reading of the "piston explosion" reminds me of something which happened to me during the past winter. I do my own firing, having but one boiler, and I have a slash bar, the handle end and bar end of which are forged of wrought-iron and welded into the body of one-inch pipe to make up the required length.

As I use the best coal I can get, I have very little clinker, yet sometimes the weld on the bar end gets burnt and loose. One day, after having it rewelded, I noticed the rod got burning hot the whole length and I had it in the fire only a short time. I thought it rather strange but the next time I put it in the fire it did the same thing. I then made up my mind that in making the weld they had left some water in the pipe, so I drilled a small hole near the handle and put the bar in the fire to heat until all the steam was out.

I really believe that there was water enough in the pipe, had the bar been used in a hot fire, to have burst it by the high pressure generated therein, which would no doubt have done considerable injury.

Grand Rapids, Mich. A. E.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Mathematical Questions.

EDITOR THE PRACTICAL ENGINEER:

Kindly answer the following questions:

1. A fan is to be bought to deliver air to a battery of boilers aggregating 400 horse power. Assuming that a pound of coal requires 230 cubic feet of air for its combustion, how many cubic feet of air per minute must the fan furnish? Assume 1 pound of coal evaporates 8 pounds of water.

2. A weight of 4800 pounds is lifted by means of a rope and two blocks, each containing 3 pulleys. The total friction is 30 per cent. of the load. *(a)*. What pull is required on the end of the rope? *(b)*. What is the smallest size hemp rope allowed so that there will be no danger of breaking? *(c)*. If the load is lifted 15 feet per minute, what is the total horse power expended in lifting it?

3. A grade is 1½ miles long and rises 600 feet to the mile; *(a)*. How much work is performed in pulling a load of 10,000 pounds up the grade, if friction is neglected, and *(b)* what horse power would be required if the work was performed in 7 minutes?

Camden, N. J. D. M. S.

1. Assuming that one horse power is equivalent to the evaporation of 30 pounds of water in one hour, the 400 horse power boilers will evaporate $30 \times 400 = 12{,}000$ pounds of water in one hour. Since one pound of coal will evaporate 8 pounds of water, 1500 pounds of coal per hour or 25 pounds per minute will be required to perform the evaporation. Each pound of coal requires 230 cubic feet of air for its combustion, so that the number of cubic feet the fan will have to furnish in one minute is equal to $25 \times 230 = 5750$ cubic feet.

2. With the above arrangement, there is evidently six ropes holding the weight of 4800 pounds, so that each rope only contains a tension of 800 pounds due to the weight. If the friction is 30 per cent., then the total pull on the rope is 1040 pounds. The breaking strain of a hemp rope can be obtained from the formula:

$$\text{Breaking strength} = 7000 \times (\text{diameter})^2$$

so that the diameter equals

$$(\text{diameter})^2 = \text{breaking strength} \div 7000$$

$$\text{or } (\text{diameter})^2 = 1040 \div 7000 = .1486$$

$$\text{therefore diameter} = .38'' = \tfrac{3}{8} \text{ of an inch.}$$

This would be the size rope that would just sustain a strain of 1040 pounds. In practice, however, it is recommended that when rope is used for driving, the working strain should not exceed $^1/_{20}$ of the ultimate breaking strength, so that the diameter would then be, worked out according to the same formula, 1¾ inches. If the load, 4800 pounds, is lifted 15 feet per minute, there will be 72,000 foot pounds of work done in one minute which is equivalent to 2.18 horse power, neglecting friction, or including the 30 per cent. friction, 2.83 horse power.

3. Since there is a rise of 600 feet to the mile and the length of grade is 1½ miles, the load of 10,000 pounds will have to be lifted 900 feet which is equivalent to 9,000,000 foot pounds of work. If the work is done in 7 minutes, 1,285,714 foot pounds of work must be done in one minute and since 33,000 foot pounds per minute is equivalent to one horse power, the horse power required will be $1{,}285{,}714 \div 33{,}000 = 38.96$ horse power.—[Ed.]

Rule for Finding Voltage of Dynamo. Speed of Motor.

EDITOR THE PRACTICAL ENGINEER:

Being a constant reader and subscriber to your paper, I desire the following information:

1. How will I find the size of wire and number of coils to build an armature; say 500 amperes, 250 volts and 250 revolutions per minute? Also, will the rule hold good for any size armature?

2. How will I determine the speed of a motor if I know the number of coils and pole-pieces?

Brooklyn, N.Y. G. J. H.

1. The design of an armature is more or less complex and depends, among other things, upon the strength of the field and the number of poles. In a 2-pole machine, if N be the total number of magnetic lines sent out by the field magnet through the armature, C the number of wires or conductors in series on the armature and n the number of revolutions per second, the electro-motive force generated will be

$$E = \frac{nCN}{100{,}000{,}000}$$

The quantity 100,000,000 is used to bring the value of electro-motive force to volts. This formula, however, applies to all sizes of dynamos and if the strength of the field, the number of pairs of poles, the number of conductors on the armature and the speed are known, the voltage can be determined. The principal variable is the strength of the field, which can only be arrived at approximately when the number of ampere turns and the reluctance of the field are known. The reluctance of the field depends upon the length of the magnetic circuit and the degree to which it is magnetized.

Therefore, if the strength of the field, the voltage and the speed of the armature are known, the number of conductors can be obtained from the formula

$$C = \frac{100{,}000{,}000\ E}{nN}$$

in which C, n, N and E have the same values as those given above.

In finding the size of the wire, sufficient cross section must be allowed in the conductors to carry the maximum current of the machine without causing a heating of the armature to such a point as to endanger the insulation. Good practice calls for from 400 to 800 circular mils per ampere, the smaller value being used in motors that do not run continuously and

the larger value for machines that run continuously, such as central station generators.

2. The speed at which a shunt motor will revolve in a constant magnetic field depends upon the voltage of the current. This voltage is counteracted by the back pressure developed by the motor armature and also by the voltage required to overcome the armature resistance. It is, therefore, necessary to know more than the number of coils and pole-pieces, the voltage of the supply mains, the load on the motor and the field strength being the important factors. The speed of a shunt motor can be, therefore, usually adjusted by either changing the strength of the current flowing through the field coils or by placing in the armature circuit a resistance that will absorb some of the line voltage.—[Ed.]

Lap for Steam Engines.

EDITOR THE PRACTICAL ENGINEER:

Will you please explain to me this question: How is the amount of lap found to cut off the steam at any desired part of the stroke?

Sydney, N. S. R. P.

The amount of lap which is required by any slide valve engine depends upon the eccentricity, the angle of advance and cut-off. The relations can best be shown by means of a diagram as shown in the accompanying illustration, which represents a Zeuner diagram.

If the eccentricity of the engine is known, describe a circle with a radius OA equal to the eccentricity and draw the vertical and horizontal diameters. The diameter of the circle represents the travel of the valve. As the eccentric must have some angle of advance, this amount is laid off from the line

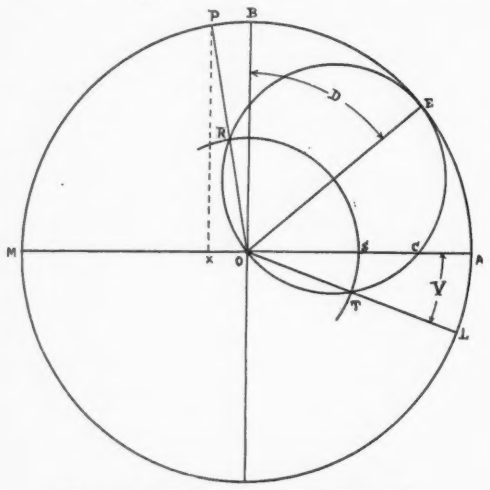


Diagram illustrating Method of Finding Lap

OB as the angle D. This angle D or OB is the angle of advance. With OE as a diameter, draw the smaller circle and you will then be in a position to determine the lap for any cut-off.

Suppose it is required to find the lap when the cut-off is 0.6 of the stroke. Lay off the distance AX equal to 0.6 of the diameter AM and draw the vertical line PX. Join the point P with the centre of the circle O. This line will cross the smaller circle at R. The distance OR will then be the lap. If the diagram has been drawn to scale, the distance OR can be measured off directly on the diagram and will give the exact amount of lap.

If the lap for any other cut-off is required, lay off the percentage of the stroke along AM, erect a perpendicular until it crosses the circumference of the larger circle and join that point with the centre O. Where that line crosses, the smaller circle will determine what the lap shall be.

After the lap has been determined according to the above method, the position of the crank when the port begins to open and the amount the port is open at the beginning of the stroke can be obtained from the diagram. For instance, OL represents the position of the crank when the port is beginning to open and SC represents the amount the port is open at the beginning of the stroke.—[Ed.]

Hydraulic Problems. Shrinkage and Forced Fits.

EDITOR THE PRACTICAL ENGINEER:

I should like to submit the following questions to your valuable paper:

(1) Would a hydraulic gauge for a 6-inch ram be all right on a 100-ton hydraulic press with an 8-inch ram, if just the pounds per square inch showed on the dial?

(2) Should the press have a safety valve set for 100 tons?

(3) How heavy should the piping be that connects the pump with the press?

(4) Is a valve that has been tested to 2000 pounds per square inch safe for a 100-ton press?

(5) Are steel castings tighter when shrunk on than when pressed on, providing the sizes are the same?

(6) Explain the use of an index plate on a gear cutter.

Lamoine, Cal. J. E. G.

(1) If the pressure per square inch is not higher than the range of the gauge, the gauge can be used.

(2) The safety or relief valve should be set for the maximum pressure per square inch allowable in the system.

(3) This depends upon the diameter of the pipe and the pressure. The regular wrought-iron pipe should never be used for a pressure much exceeding 350 or 400 pounds per square inch. If the pressure exceeds that, then extra-heavy or specially-constructed pipe should be used.

(4) For most hydraulic systems, the value would be safe, as a pressure of 600 or 700 pounds would be the maximum carried.

(5) A shrunk joint is generally considered a tighter joint than those forced on. The principal objections to it are the exact dimensions which are necessary and the liability of strain and injury to the casting. Therefore, a forced fit is generally used and for most practical purposes it answers all purposes. In a shrinkage fit or joint, the piece containing the hole is expanded by heating until the part, which it is to embrace, can be entered and the subsequent contraction holds it tight. In forced fits, the shaft or material is forced to enter the hole, the elasticity of the material being depended upon to make the joint secure. The fitting of locomotive tires to the body of the wheels may be cited as an example of the shrinkage fit, and the fixing of crank pins into the cranks of engines may be taken as illustrating forced fits.

(6) This will depend upon the kind of gear cutting machine used. The index plate of a milling machine contains a num-

ber of holes and the index arm is connected to a single threaded worm which is connected to a worm wheel having 40 teeth. The index arm must therefore revolve 40 times in order to make the work revolve once. By a recently-devised system of differential indexing, one revolution of the index arm will, when turned in one direction, produce 39 spaces and when turned in the opposite direction 41 spaces, so that any fractional spacing may be handled. As each indexing device on each make of machine is different, they must be individually studied to be understood.—[Ed.]

Electrical Questions.

EDITOR THE PRACTICAL ENGINEER:

Kindly answer the following questions in your next issue:

1. Why does the speed of a series or shunt wound motor increase when the field current is decreased?

2. Explain the advantages of the shunt, series and compound wound dynamos.

3. What is meant by the term "phase"?

4. Why will an incandescent lamp burn out if a 120 volt lamp is connected across wires of 240 volts?

5. Why cannot a transformer be used for direct current, because on an induction coil, direct current is used? Is the current in the secondary of an induction coil alternating, if that in the primary is direct, and why?

Detroit, Mich. C. E. B.

1. When the armature of a motor revolves, it differs in no respect from the same armature when it is being driven as a dynamo. There is in each case an electro-motive force generated in it which is determined by the speed and strength of the field. For the same speed and same field strength there will be generated the same electro-motive force in the case of a motor as in the case of a dynamo. The direction of the electro-motive force in a motor is, however, the reverse of what it would be in a dynamo, and hence is called the counter electro-motive force. Now it is this counter electro-motive force which tends to reduce the speed of rotation of direct-current motors because the faster the armature rotates, the great will be the counter electro-motive force produced. When, therefore, the field strength of a motor is reduced, the load on the motor remaining constant, there is only one way for it to generate its required counter electro-motive force and that is to run faster, which it does.

2. The advantages of the three types of motors depend upon the uses to which they are put. The series motor is used where it is necessary to start under a full load and where constant speed is not necessary, such as for street railway service, hoists or cranes. A shunt motor is used extensively where the speed of the motor must be fairly constant. The speed of a good shunt motor should not vary more than 5 per cent. from zero to maximum load. In silk mills or in textile factories, where any slight variation in the speed affects the character of the manufactured product, compound motors are used. The field coils are so compounded that as the load increases, the field strength is weakened, so that the speed will remain constant.

3. When the current and electro-motive force in a circuit are both maximum and minimum at the same moment, the current and electro-motive force are said to be in "phase." In practice, however, except in non-inductive circuits, the current will either lead or lag the electro-motive, so that the current is said to be out of step or out of phase with the electro-motive force.

4. The increased voltage heats up the carbon filament beyond its fusing point and the weakest part of it breaks, when the lamp is said to have burnt out.

5. A transformer depends upon the changing of the value of the electro-motive force in the circuit for its action and hence a direct current would not set up induction currents in the iron core of the transformer. In an induction coil the effect of induction is produced in the secondary coil by making and breaking the primary circuit rapidly. The result of this making and breaking is to induce in the outer secondary at every break a powerful momentary direct current. There is usually an inverse current formed at make but the use of a condenser with an induction coil suppresses the inverse current and greatly increases the direct electro-motive force at "break." —[Ed.]

Unit of Refrigeration. Amount of Cooling Pipe Required.

EDITOR THE PRACTICAL ENGINEER:

Would you kindly give me some information regarding the figuring of refrigeration? How many feet of 2-inch ammonia pipes would it take to keep the temperature at 32 degrees Fahr. in an 80 x 65 x 12 foot well insulated room? Also, would you please tell me which is the most economical way: To run my Corliss engine 26 x 48 condensing, showing 26-inch vacuum, the boiler feed will have a temperature of 194 degrees; or to run non-condensing, which will give feed water 212 degrees and one pound back pressure on the exhaust?

Milwaukee, Wis. S. A.

The refrigerating unit used for all calculations is based upon the cooling effect or work done by the melting of one ton of ice and is called the refrigerating capacity. This is usually given as "tons of ice melting capacity" per twenty-four hours' continuous operation.

The cooling effect of a ton of ice is equal to 284,000 British Thermal Units; that is, the unit of refrigeration is capable of cooling 284,000 pounds of water one degree, or 28,400 pounds ten degrees, etc. Dividing this work equally through the twenty-four hours, the actual duty which is represented by the term "one ton ice-melting capacity per twenty-four hours" would equal the cooling of 197.2 pounds of water one degree every minute or 11,833 pounds one degree every hour of the twenty-four hours.

The following table gives approximately the space that can be cooled per ton of refrigerating capacity per twenty-four hours' continuous operation for different temperatures:

10,000 cubic feet of space	Temp. 40°.
6,000 cubic feet of space	Temp. 32°.
3,000 cubic feet of space	Temp. 20°.
2,000 cubic feet of space	Temp. 10°.
1,500 cubic feet of space	Temp. 0°.

The above figures are based on plants which are properly piped and insulated.

In the above problem, the room being 80 x 65 x 12 feet, the cubical contents to be refrigerated are equal to 62,400 cubic feet. The amount of pipe necessary depends upon the system of refrigeration used. Storage rooms refrigerated on the direct expansion system require one foot run of two-inch

piping for every 45 cubic feet of space; if the brine-circulating system is used, it will require one foot of two-inch pipe for each 15 cubic feet of space, which gives about 1480 feet for the direct system and 4160 feet for the brine system. The above quantities are the minimum which should be used.

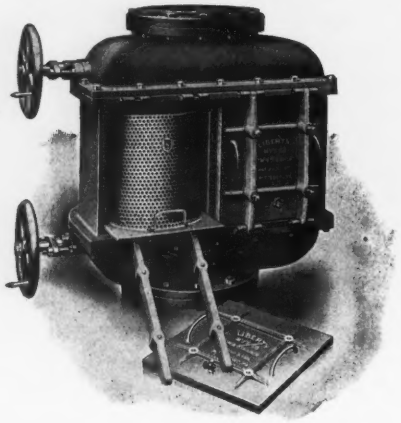
The plant would be more economical if run condensing, other conditions being favorable, unless you had to use the condensed steam for can ice, when it would be more economical to run non-condensing.—[Ed.]

The Twin Strainer.

Manufacturing and power plants obtaining their water supply from lakes, rivers, creeks and canals, must employ some means for removing foreign solid matter from the water in order to protect the pumps, condensers and other machinery from becoming clogged. The ordinary foot-valve strainer when it becomes clogged is inaccessible and requires a large amount of work to remove its obstructions. To overcome this difficulty, the Twin Strainer, shown in the accompanying illustration, was designed, as it can be conveniently located and cleaned without affecting the water flow.

The Twin Strainer, as its name applies, consists of two strainers in one, which are alternately thrown in or out of action by simply operating a pair of valves, the strainer not in use being accessible for cleaning.

The apparatus consists of a casing having two passage ways, each containing a basket shaped strainer securely fastened, but which is removable. By an arrangement of valves, the flow of water or other liquid to be strained is made to pass through one basket while the other is being cleaned and replaced.



The Twin Strainer

Access to the basket for cleaning is had through doors in the front of the casing and as the basket to be cleaned is not under pressure or suction, as the case may be, it can be removed, cleaned and replaced in a few minutes, the door replaced and the basket again ready for service. On account of this ease and rapidity of manipulation, the strainer will handle water containing any amount of solid matter.

The Twin Strainer is being used on injector lines, boiler feed lines, for jet condensers, circulating, turbine and centrifugal pumps and on the suction lines of fire pumps and other apparatus which require water free from obstructions. For further particulars address the manufacturers, Liberty Manufacturing Co., 6409 Susquehanna Ave., Pittsburg, Pa.

Valve Files.

When the hard rubber disc was invented and perfected, it marked a new era in the history of valves, because it is no longer necessary to resort to the tedious operation of grinding in a leaky valve. The worn-out disc can be removed and a new one put in without removing the valve, and the whole operation occupies but a few minutes, making the valve as good as new.

Valve File

This means that the valve will be tight provided the seat is in good condition, but this is not always the case. Sometimes such a valve will leak, and when the disc is taken out it will be split into two or more pieces. This indicates that the seat is out of order and should be repaired without delay.

When the bonnet of the valve is removed, the seat may appear to be in perfect order, as it is bright and clean with no bad spots or holes in it. This appearance is often deceptive, because the seat is not true but is higher in some places than in others, consequently when the disc is forced down in closing the valve it breaks the disc.

By inserting a valve file and turning it through three or four revolutions under light pressure, it will point out these high and low places very plainly. A few more revolutions under greater pressure will entirely remove the bad feature and leave the seat in as good a condition as when new. Or, should a small piece be broken out of a valve seat, a valve file will file the seat down until it is perfectly true, so that when the new disc is put in there will be no leak.

The accompanying illustration shows one of these valve files in place ready to be used. By putting on a common bit stock and turning it, the valve seat is reground. Each file is capable of repairing valves of seven sizes. For further information address, W. H. Wakeman, 64 Henry St., New Haven, Conn.

Louisville Engineers.

The Steam Engineers' Club, of Louisville, Ky., which was organized in March, 1905, with 46 charter members, now has over a hundred members and is growing steadily. Their educational committee is doing some good work, conducting practical tests, and the meetings are well attended. This Club also maintains a permanent employment committee, the duties of which are to look out for positions and to advance the interests of its members. They inform us that this employment committee has done good work during the past year, having filled many new positions and advanced a number of their members to positions commanding better salaries.

The Milwaukee Convention of the A. O. S. E.

Out in Milwaukee, that delightful city where beauty, health, happiness and industry abound and thrive like palms in the everglades, forming a quartet which charms the visitor in their midst and sends him homeward bound cherishing many a fond remembrance which will live in after years to return and cheer his melancholy moments like the fleeting thoughts of his first love; where the waters of Lake Michigan, washing right up to the very doorstep of the city, and bearing on their bosom hundreds of handsomely bedecked steamers and small pleasure craft of every description, giving it the effect of a beautiful fairyland reaching far out over the waters, and bringing health in abundance to the city's inhabitants and beauty to its women folk; where the broad, clean streets, shaded by stately elms and lined on either side with pretty homes, each surrounded by a grassy lawn and pretty flowers, lend an air of purity and sweetness not surpassed in any other American city; where the two largest breweries in America are located and where the beautiful palm gardens, with their matchless beers, choice music and always jolly family gatherings, are a neverending source of pleasure to visitors, and where the Allis-Chalmers Company have erected one of the largest and most modern engine building establishments in the whole world—Amidst these delightful surroundings, on the 11th, 12th and 13th of June, the Supreme Council of the American Order of Steam Engineers held their Twentieth Annual Convention.

The arrangement for the business sessions and for the comfort, convenience and entertainment of the visiting officers and delegates were provided by the Milwaukee members of the Order, with Mr. J. T. Harris as chairman. The official headquarters were at the St. Charles Hotel and the business sessions were held in Freie Gemeinde Hall. An exhibition of engineers' supplies and power plant equipment was held in the same place and the result was a very satisfactory convention.

There were upwards of 40 delegates and officers present, representing all but one or two of the 18 Councils of the Order, which have a total combined membership of nearly one thousand members.

The entertainment was all that generosity could provide and was a constant delight to all who attended. There was a boat ride to Whitefish Bay, which provided fun enough and to spare; a banquet fit for kings and a visit to the Pabst Brewery, where a delightful luncheon was served in a tent provided for the purpose, not to mention a hundred and one minor features which kept the visitors busy from the time they reached Milwaukee until they departed.

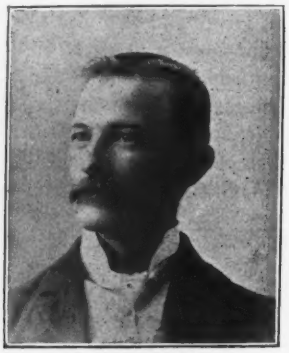
The banquet was held at Blatz Hotel on Tuesday evening. Past Supreme Chief H. M. Trout, of Reading, Pa., officiated as toastmaster. Among the speakers were Supreme Chief A. J. Dietrich, Past Chief Noah Pierson and Mr. Tomlinson, President of the National Association of Stationary Engineers.

Delegates and Visitors to the Twentieth Annual Convention of the A. O. S. E.

A pleasant feature of the Convention was the presentation, by Past Supreme Chief Lightfoot in the name of the Supreme Council, of a gold trimmed umbrella to retiring Supreme Chief Trout. J. T. Harris, the popular chairman of the Convention, was also presented with a gold mounted umbrella by the Supreme Council, and with a handsome Morris chair by the exhibitors of machinery and supplies.

The principal business transacted by the Convention was the election of officers for the ensuing year, which resulted as follows: Supreme Chief, A. J. Diedrich, Baltimore, Md.; First Assistant Supreme Chief, Joseph T. Harris, Milwaukee; Recording Engineer, E. H. Naylor, North Abington, Mass.; Corresponding Engineer, Frederick Markoe, Philadelphia; Treas-

urer, W. J. Gifford, Philadelphia; Senior Master Mechanic, L. Souders, Germantown, Pa.; Junior Master Mechanic, W. J. Eccles, Philadelphia, Chaplain, James Lightfoot, Philadelphia; Inside Sentinel, Walter Long, York, Pa.; Outside Sentinel, W. R. Smith, Allentown, Pa.; Trustee, H. M. Trout, Reading, Pa., with J. C. McDowell, Philadelphia, and W. S. Price, Atlantic City, hold-overs. The new officers were installed on Wednesday.



A. J. DIEDRICH,
Supreme Chief A. O. S. E.

The election of Mr. Diedrich as Chief Engineer could not well be improved upon. He is a splendid fellow, deservedly popular with all who know him and an engineer of unquestioned ability. He is chief engineer of the Continental Building, the finest office building in Baltimore.

Atlantic City was selected as the place for holding the next Convention and the bare announcement of that fact is sufficient guarantee of a good time, for the Atlantic City engineers are widely known as generous entertainers and all those who attended the Convention of 1900, held at that popular resort, will undoubtedly endeavor to attend next year.

THE SUPPLY MEN.

Among the most popular of the supply men present were: Wm. G. LeCompte, the well-known representative of Jenkins Brothers, who was everywhere all the time and always with the same merry little twinkle in his eye.

Mr. Silas Cook, representing the manufacturers of Albany Grease, was new to an A. O. S. E. Convention, but proved a decided favorite and made many friends.

JOSEPH F. HARRIS,
Assistant Supreme Chief A. S. O. E.

Mr. Beckmeyer, of the Lunkenheimer Company, was also a favorite, as was also Mr. Ward, of the Dearborn Drug and Chemical Works. Mr. Hopper, of the Keystone Lubricating Co., and Mr. Morris, of the Geo. W. Lord Co.

THE LADIES.

Mrs. J. T. Harris and several other Milwaukee ladies organized for the purpose of entertaining the visiting ladies and it is only fair to them to say that they were delightful entertainers and the visiting ladies will long remember the occasion. On Monday afternoon the ladies visited the Soldiers' Home. In the evening they visited the Exhibit Hall, where they were agreeably entertained by Mr. Jack Armour. Tuesday afternoon they accompanied the men on the boat-ride to Whitefish Bay and the city pumping station. In the evening, while the delegates were enjoying their banquet at the Blatz Hotel, the ladies were occupying a box at the Davidson Theatre. On Wednesday they took carriage rides about the city, visiting Lake Park, Schlitz's Brewery and other points of interest and on Thursday—well, the ladies visited the department stores. Now, you can't blame a lady for that, and the fact that they delayed it until the last day, recalls a trait of those school days, when it was the never failing habit to save the ripest peaches to the last.

Annual State Convention of the Pennsylvania N. A. S. E. State Association.

The Eighth Annual Convention of the Pennsylvania State Association was held in Altoona, Friday and Saturday, June 1st and 2d, eighteen delegates besides the State officers being present. The Convention was opened at 10 A. M. on Friday by Mr. John C. Wollin, of Williamsport, president of the Association. The president then appointed the different committees after which a recess was taken until the credential committee made their report. The delegates were then seated and the reports of the secretary and treasurer were read and approved. They showed the State Association to be in a good financial condition and that the membership was doubled during the past year, reflecting great credit on the efficiency of the State officers.

On Friday afternoon, a short business session was held after which the delegates and visitors were taken on a trolley ride through Altoona, visiting the large shops of the Pennsylvania Railroad and several electric light and power stations. The evening was devoted to a business session at which the license question was discussed and plans were laid so that the law now on the statute-books could be made more effective. A number of business men and employers of engineers were present at this meeting and they were favorably impressed with the manner in which the business was handled by the delegates and officers. At 9.30 P. M. the session adjourned to the Hotel Altamonte, where an elaborate banquet was given to the delegates by the local committee. About 75 persons were seated around the festive board and listened to addresses by Past State President S. B. Forse, State President John Wollin, Vice-President John Lewis, State Secretary Albert M. Munzinger, State Treasurer Enoch Carless, State Deputy President Richard Pape, H. E. Sibson of the Harrison Safety Boiler Works, Mr. Howe of the Quaker City Rubber Co., and several prominent citizens of Altoona. Among the supply men present were Columbus Dill of the Ashton Valve Co., Charles Hopper of the Keystone Lubricating Co., L. P. Clark of the Geo. W. Lord Co., and Frank H. Waite of McLeod & Henry Co. Past National President Charles H. Garlick acted as toastmaster.

At the Saturday morning session, the principal business was the nomination and election of officers, which resulted as fol-

lows: President, Edward Murphy, of Pittsburg; Vice-President, John Buggy, of Chester; Secretary, Albert M. Munzinger, of Williamsport; Treasurer, Enoch Carless, of Philadelphia; Conductor, John Dallas, of Sharon; Doorkeeper, A. C. Cotton, of Altoona. The meeting adjourned to meet next year at Sharon, the date being set for June 7th and 8th, 1907.

On Saturday afternoon, the delegates and visitors were taken to Hollidaysburg on a special and on the return trip a stop was made at Lakemont Park, where the final good time was had.

Model Engineers.

At the monthly meeting of the American Society of Model Engineers, held at the Berkeley Lyceum, on Wednesday evening, a very interesting lecture was delivered by Mr. K. Stoye, instructor in the Baron de Hirsch Trade School.

The lecturer explained the use of the lathe and lathe tools with special reference to model making. Almost every important implement required in lathe work was explained and a great number of tools and appliances were illustrated, which proved to be new to most of the members. Of particular interest and value was the description of some difficult operations on the lathe, as for instance, deep accurate boring, chucking intricate pieces of work, the use of the lathe as a shaper, etc.

It was decided to adjourn during the hot months and commence early in the fall with a series of lectures and instructive talks interesting to model makers. Applications for membership should be made to Mr. W. E. Spon, 123 Liberty St., New York City.

Fifth Annual Convention of the Michigan State Association, N. A. S. E.

The Fifth Annual Convention of the Michigan State Association of the N. A. S. E. was held at Grand Rapids, Michigan, on June 1st and 2d. The Convention was opened with an address of welcome by Stanley Jackowski which was responded to by E. G. Jacques. The State President, E. C. Smith, then delivered his address, which was full of good pointers and was listened to attentively by the fifty delegates and 250 members of the Association who were present. Reports of the officers were heard which showed the Association to be in a prosperous condition. License legislation took up a large part of the discussion and the Association placed itself on record as favoring such a law.

The social event consisted of an interesting and musical program after which refreshments were served to the 400 engineers and their wives and friends who were present.

In connection with the Convention, there was an exhibition of engineers' supplies in the exhibition hall. The booths were attractively arranged and the arrangement of engineers' supplies attracted considerable notice. Some thirty well-known manufacturers were represented.

The election of officers resulted as follows: President, Chas. E. Davey, Detroit; Vice-President, Waldo Francisco, Grand Rapids; Secretary, John H. Brandell, Owosso; Treasurer, A. B. Lafranier, Bay City; Conductor, Arthur C. Benton, Battle Creek; Doorkeeper, Geo. Trumbull, Flint; Trustee, John Andrews. Detroit was chosen as the next meeting place.

State Convention of the California N. A. S. E.

The third annual convention of the State Association of the California N. A. S. E. was held in Fresno, California, on May 30th and 31st, twenty-four delegates besides the officers of the Association being present. May 30th, Decoration Day, was devoted principally to pleasure, all the delegates and their ladies being treated to a fine trolley ride in the afternoon and a vaudeville performance in the evening.

The business sessions were devoted to the discussion of license laws, the place of the next convention and election of officers for the ensuing year. San Jose was selected as the next meeting place, the exact date being left to the engineers of that city. The following officers were elected: President, Roderick McKay; Vice-President, Harry D. Saville; Secretary, W. T. Curl; Treasurer, J. N. Pyster; Conductor, A. M. Bradley; Doorkeeper, Charles Knight; Trustees, J. B. Williams, E. A. Stanley and W. P. Stevens.

The convention was delightfully ended with an elaborate banquet at which the ladies' auxiliary of Fresno Association acted as hostesses. Besides the delegates and invited guests, many of the local members attended. Mayor W. P. Lyon welcomed the delegates and Judge Short made an address on the subject of Engineers' License Laws.

Book Reviews.

Mechanical Draft, by J. H. Kinealy. Size, 4½ x 6¾. 140 pages, 13 illustrations and 27 tables. Published by Spon and Chamberlain, 123 Liberty St., New York City. Price, $2.00.

In writing this book, the author has assumed that those who use it are familiar with boiler and engine plants and he has had in mind the practicing engineer who is called upon to design power plants and who must therefore decide when it is best to use some form of mechanical draft.

The contents of the book include the general discussion of the systems of mechanical draft, including forced draft and induced draft; fuel and air required for economical combustion; draft required for different conditions; economizers and types and design of fans.

The book is well written, in a clear and authoritative manner, which proves that the author has had considerable experience in the field of mechanical draft. The tables are especially valuable as they tell exactly what the practical man wants to know and as they are new, they have added considerably to the engineering knowledge on this subject.

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

The arrangement of the tubes, the easy method of cleaning and the general simplicity of the Patterson-Berryman Feed Water Heater seems to have made it a decided favorite among operating engineers wherever it is known. The builders have recently been obliged to increase their capacity. They also make Separators, Exhaust Heads and Belt Pumps. A catalogue describing all of these will be mailed free upon request. Address F. L. Patterson & Co., 24 Cortlandt St., New York.

After nearly forty years Albany Grease rightly comes into its own, and takes its place alongside of the registered "boy on the plank," made so familiar by Adam Cook's Sons, to every engineer. Under the old trade-mark law, the word "Albany," being a geographical name, could not be registered. The new law passed February 20, 1905, has changed this, and now affords protection to concerns who have put the names of such cities as Albany, Milwaukee, St. Louis and Manhattan into the mouth of every man.

The name "Albany" in connection with grease, is now the sole property of Adam Cook's Sons, being duly registered in the United States Patent Office, at Washington, D. C. The certificate was presented to Adam Cook's Sons, under date of February 13, 1906, by Uncle Sam on May 1, 1906, and they are to be congratulated on the protection Uncle Sam now affords them.

We have received a letter from Lippincott Steam Specialty and Supply Co., of Newark, N. J., which will interest engineers who like ourselves, have often wondered just how much service an indicator would stand. The letter follows:

"Having heard many arguments concerning the probable life of an engine indicator, we took from stock one of our regular high-pressure pattern instruments with frictionless piston, and on May 9th placed this in possession of Mr. William V. Barr, engineer of the Richardson Building, Newark, N. J., at which time he connected it to a high-speed engine operating under a steam pressure of a hundred pounds, the spring used being fifty. This instrument was oiled but twice a day during the run and with the exception of the loosening of one screw no accident happened during the run.

"This instrument during this test made One Million, Five Hundred and Ninety-three Thousand, Seven Hundred and Sixty (1,593,760) strokes, and, at the end of the test, the cylinder and piston were in perfect condition, and upon giving a slight adjustment to the taper screws which carry the pencil motion, the instrument was apparently in as good order as when it started.

"A diagram taken with it showed it to be just as sensitive. A rigid test of the spring after the test was completed, showed that it had not changed to any noticeable extent, which certainly proves that temperature does not have a bad effect upon such springs, and that they are capable of standing more severe usage than they ever get in ordinary practice.

"It is safe to assume that during the above test this instrument was subjected to more wear than it would probably get in the lifetime of any engineer, and would probably prove equally serviceable for his son and grandson."

Mr. C. T. Allen, for many years the treasurer and active head of the Union Steam Pump Co., of Battle Creek, Mich., has retired from active participation in the Company on account of ill health. The control of the Company is now in the hands of Mr. Chas. E. Kolb, Mr. L. B. Anderson, Mr. Homer A. Latta and Mr. Ila N. Moore. These gentlemen have all been connected with the Company for many years and are well known to the trade as well as deservedly popular.

Leviathan Belting is peculiarly adapted for use in mines, paper mills, outdoor service of every kind and any place where the belting is exposed to attack from water, steam, acid fumes or extreme changes of temperature, where leather or rubber belts wear quickly. It is made of a specially woven duck which is stitched through in a manner that practically welds it into a single thickness after which it is subjected to a special treatment which gives it long life under the most adverse conditions. The makers of this belting have issued a booklet which tells of its manufacture and its adaptability in an interesting way, a copy of which will be mailed to anyone. Address the Main Belting Co., 1225 Carpenter St., Philadelphia.

The Twin Strainer, built by the Liberty Mfg. Co., 6905 Susquehanna St., Pittsburg, Pa., which is described elsewhere in this issue, is a splendid thing for the suction pipe, especially where the feed water is taken from a river or pond where there is likely to be trouble with fish, leaves, twigs or other obstructive matter. A pamphlet which describes and illustrates this strainer very comprehensively is issued by the makers and they want to send a copy to anyone interested. Address as above.

We want to say to you that John H. Foote, the popular representative of McLeod & Henry, Troy, N. Y., was one of the callers at the offices of THE PRACTICAL ENGINEER during the past month and he says that they are guilty—that "Steel Mixture" has no equal.

The advantages of movable grates over the ordinary stationary grate bar are generally admitted by engineers. It is well known that the opening of fire doors for long periods to clean causes a loss that soon eats up the small difference in cost to say nothing of the damage to the boilers caused by the cold drafts thus admitted over the fire, but the difficulty has been to get a movable grate that would clean the fire satisfactorily without dropping unburned fuel and without disturbing the surface of the fire more than was good for it. The New England Roller Grate is so constructed that the bars are always level, whether in motion or at rest, the arrangement and movement of the bars is such that there can be no dead spots and no obstruction to the air spaces. The whole grate is supported by and moved upon anti-friction rollers, hence the movement is positive and easy. Over 6000 sets of these grates are said to be in use in New England. They are manufactured by the New England Roller Grate Co., 310 Main Street, Springfield, Mass. The manufacturers will send a catalogue upon request.

Indicators FOR SALE ON EASY TERMS
REDUCING WHEELS
PLANIMETERS
See LIPPINCOTT AD on third cover page

FOR SALE—Indicator outfit at a sacrifice on account of having no further use. Write for particulars. Address Widow. Care Practical Engineer, Phila., Pa.

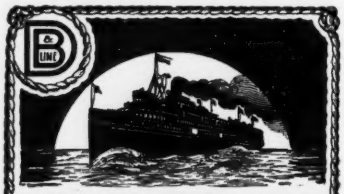
Wanted A few good and competent engineers along the Ohio, Mississippi and Kanawah Rivers, to sell the best thing on earth. This can be done after working hours and between times. Address, J. L. TILLMAN, 521 Colburn Street, Toledo, Ohio.

Wanted Salesmen traveling among engineers to sell the France Metallic and Fibrous Packings. Good inducements on unoccupied territory, Address
FRANCE PACKING Co., Tacony, Phila., Pa.

PATENTS Watson E. Coleman, Patent Attorney, Washington, D. C. Advice free. Terms low. Highest ref.

PATENTS Procured ISEDORE S. PRENNER, E.E. Attorney-at-Law, Solicitor of Patents, Consulting Engineer, Law, Patent and Engineering Cases.
Room 1108 Betz Building, Philadelphia.

PATENTS PROMPTLY SECURED. Highest references from prominent manufacturers. Write for Inventors' Hand-Book, SHEPHERD & PARKER, 186 Deitz Building, Washington, D. C.



THE WATER WAY
BETWEEN
Buffalo and Detroit

The D. & B. Line Steamers leave Buffalo daily at 5:30 p.m. (eastern time) and Detroit week days at 5:00 p.m., Sundays at 4:00 p.m. (central time) reaching their destination the next morning. Direct connections with early morning trains. Lowest rates and superior service to all points west.

Rail Tickets Available on Steamers

All classes of tickets sold reading via Michigan Central, Wabash and Grand Trunk Railways between Buffalo and Detroit, in either direction, will be accepted for transportation on D. & B. Line Steamers. Send 2 cent stamp for illustrated pamphlet. Address
A. A. SCHANTZ, G.S. & P.T.M., Detroit, Mich.
Detroit & Buffalo Steamboat Co.

The Buckeye Boiler Skimmer Co., of Colburn Ave., Toledo, O., have recently installed a number of their famous Buckeye Skimmers in plants located in Philadelphia and vicinity, in all of which they are giving the greatest possible satisfaction. In Sykes Bros.'s mill at Hancock and Huntingdon Streets, the engineer said: "It is the best thing that ever come down the pike." At John Hamilton & Son it is doing equally good work in removing mud and sediment from the boilers. Among the larger installations were the Bellevue-Stratford Hotel and the Schoen Steel Wheel Co. The Macbeth-Evans Glass Co., of Pittsburg, recently ordered three Buckeye Skimmers, since which time they wrote the manufacturers as follows:

GENTLEMEN: About a month ago we installed three Buckeye Boiler Skimmers in our boilers at Marion, Ind., plant, and it seems from reports we have received from our factory that these skimmers are giving entire satisfaction in every respect.

The factory writes they have not been troubled with foaming boilers, nor have they any trouble in keeping up steam.

They say that beyond any question the skimmers are a success, and it is wonderful the amount of sediment they blow out of the boilers.

Wishing you success, we beg to remain, Macbeth-Evans Glass Co.

Mr. Paul T. Buckler, formerly with the Cancos Mfg. Co., of Philadelphia, and later with the Pennsylvania Electrical and Railway Supply Co., of Pittsburg, has accepted a position with Harry W. Pickett, in charge of his new branch office, 310 Krise Bldg., Lynchburg, Va., carrying a line of railway equipment and supplies.

The Foster Engineering Co., of Newark, N. J., have opened a new branch office at 631 Arch St., Philadelphia, with Mr. Thos. Brannon in charge. Mr. Brannon is well known and popular with the trade in this city and with the splendid line of specialties manufactured by the Foster Co. his success is assured.

A new automatic boiler cut-off valve has recently been placed on the market by the Lagonda Mfg. Co., of Springfield, Ohio. The advantages claimed for this new valve entitle it to consideration. If the steam header should break it automatically shuts off all the boilers. If a boiler tube fails it shuts off that boiler, while the others are continued in service. It has some other interesting features which are described in a booklet just issued by the Lagonda Co. Write for a copy if you are interested.

The American Society of Refrigerating Engineers have issued their 1906 year book which contains a complete list of their members with their addresses and also tells about the objects of the Society. Anyone who wishes a copy can procure one by addressing the secretary, Mr. W. H. Ross, 258 Broadway, New York City, Room 208.

Dodge & Day, engineers, of Philadelphia, have completed plans for the new works of the Arthur Koppel Company, of New York and Berlin, Germany. Construction work will be started at once and the plans contemplate the immediate erection of a section of the erection shop, the light car shop, the switch shop, service building and office building and a part of the power plant. The works are situated at Homewood, a place about 35 miles from Pittsburg, and will make many of the products which have hitherto been imported by the Arthur Koppel Company from Germany. Mr. H. A. Ellis will have charge of the new works and is now arranging for the building of the plant. He has established an office at 1771 Frick Building Annex, Pittsburg, Pa.

The use of feed water regulators in power plant practice is becoming the rule instead of the exception, and engineers are beginning to appreciate their value as economy and efficiency producers. In fact, the modern plant would be as much at sea without a safety feed water regulator as it would without a pop valve.

The Williams Gauge Company, of Pittsburg, Pa., manufacturers of the Williams Safety Feed Water Regulator, announce a few of their recent sales together with the horse power below:

Illinois Central R. R., 1200 H. P.; D. L. & W. R. R., 25,000 H. P.; Republic Iron and Steel Co., 15,000 H. P.; Tenn. Coal, Iron and R. R. C., 10,000 H. P.; Penna. Coal Co., 7000 H. P. ; Amer. Car and Fdry. Co., 9000 H. P.; Morgan Engineering Co., 2000 H. P.; Westinghouse E. and Mfg. Co., 2000 H. P.; N. Y. Central and Hudson River R. R., 3000 H. P.; Pullman Palace Car Co., 2000 H. P.; Illinois Steel Co., 4000 H. P.; Carnegie Steel Co., 3000 H. P.; Crucible Steel Co., 4000 H. P.; Boston and Maine R. R., 1200 H. P. The total boilers equipped to date with the Williams Safety Feed Water Regulators will aggregate 4,100,000 horse power.

The C. A. Dunham Co., Marshalltown, Iowa, have recently opened a branch office at 609 New England Building, Cleveland, Ohio. Mr. E. G. Beeson, secretary of the above Company, is in charge, and will look after their interests, and the interests of its customers through that section.

If you are interested in a fine line of machine tools write L. S. Starrett Co., Athol, Mass., and ask them to send you a copy of Catalogue No. 17.

The Reeves engine catalogue contains a lot of good engineering information for those who are contemplating the purchase of an engine and want to know the reason why. It will be mailed to those who write for it. Address Reeves Engine Co., Trenton, N. J., or see W. E. S. Dyer, manager of their Philadelphia office in the Land Title Building.

The "Penberthy Engineer and Fireman," a 32-page magazine, will be sent free for 3 months to all who send their address to Penberthy Injector Co., 344 Holden Ave., Detroit, Mich.

Copes Automatic Feed Water Regulator is highly recommended for house tanks and elevator tanks as well as for steam boilers. In a steam plant near the offices of THE PRACTICAL ENGINEER one of these regulators has been in constant service for the past nine or ten years and the engineer says he would not part with it for several times its cost. They are installed by Wilfong & Wiltbank, 420 Mutual Life Bldg., Philadelphia. A catalogue will be mailed for the asking.

If you have any second-hand belting on hand which you would like to dispose of, or if you want to buy a second-hand belt of any size for any purpose write to W. T. Shackley & Sons, 49 High St., Boston., Mass. They are large dealers in second-hand belting, and absolutely reliable.

Holmes Metallic Packing Co., Wilkesbarre, Pa., have sent us a photograph of a recent shipment of sixteen of their packings all of which were for 13-inch rods and they write us of several similar orders, which they now have in hand. A catalogue describing the Holmes Metallic Packing will be sent upon request.

Catalogue "D," published by the Ashton Valve Co., 271 Franklin St., Boston, Mass., is a splendid reference book when one is contemplating the selection of steam, and vacuum gauges, recording gauges, pop valves, relief valves, etc. The catalogue is of the same high quality throughout as the gauges made by this well-known old concern and every engineer who is interested in this class of goods should consult it.

The American Water Softener Co., 1002 Mutual Life Bldg., Philadelphia, have a method of softening boiler feed water that should interest every engineer and student of water treatment. Their method is described in their catalogue, a copy of which will be mailed to readers upon request.

In their new shops at 621-23 Cherry St., Philadelphia, The Hub Machine and Tool Co. are as busy as bees. They have been adding new tools and machinery right along and are now prepared to handle all kinds of repair or general machine work. They are experts on engine and pump repairs, but are also well fitted out for general and special machine work of all kinds.

PACIFIC COAST AGENTS

A new booklet just issued under this title should be in the hands of every person who expects to make a trip west of the Rockies this year.

It outlines all the routes to the Coast, shows maps of each, contains a large map of the country from the Great Lakes to the Coast and has a great deal of valuable information about side trips, interesting sights, etc.

The booklet is finely printed and handsomely illustrated. Its use will save you the trouble of getting and combining the separate booklets of the many different roads reaching the Pacific.

Your request on a postal, mentioning the name of this paper, will bring a copy by return mail. P. S. Eustis, Passenger Traffic Manager, Chicago.

Ventilators of every description are manufactured by the Sterling Blower and Pipe Mfg. Co., Hartford, Conn. This Company also make special apparatus for removing dust from wood working establishments, cement mills, flour mills, grain warehouses or any place where it is necessary or desirable to get rid of dust. They also build special apparatus for handling shavings and sawdust to be fed to boilers. They have a reputation for high-class work and square dealing.

The General Specialty Co., 75 Carroll St., Buffalo, N. Y., are offering to send one of their boiler tube cleaners on free trial. An offer of this kind may generally be accepted as proof of merit, for it shows beyond question that the manufacturers have confidence in their machines.

The Thompson Damper and Pressure Regulator, and also the Thompson Special Regulator for paper machines are both fully illustrated and comprehensively described in a new catalogue just received from the manufacturers. This damper regulator has the power to move the damper or any number of dampers in both directions by water pressure, and is not necessarily wide open or shut. It has some other interesting features which are shown in the catalogue. Messrs. Thompson & Co. inform us that they have met with highly satisfactory results with their special regulator for paper machines. It is used for regulating exhaust and live steam in paper cylinders. Those who are interested should write for a copy of this newest catalogue to Richard Thompson & Co., 126 Liberty St., New York City.

Asbestos building lumber, though largely used in Australia and in some of the European countries, is a new thing in America and one which marks an epoch in the furnishing of fireproof building material. It is a composition of asbestos and cement and is turned out in many forms, the most popular being shingles and sheathing, which latter resembles the ordinary corrugated galvanized-iron sheathing, and owing to its great durability and the fact that it is absolutely fireproof makes it especially desirable for the construction of boiler houses or outbuildings of any kind. It is said that it will last for generations and does not require paint or other protection. For further descriptive matter, prices, etc., address, the makers, Keasby & Mattison Co., Ambler, Pa.

A new method for sterlizing, purifying and softening water which is attracting attention is known as the Electrolytic Process. This new purification method, instead of driving free oxygen from water, liberates an excess of this important element which purifies and sterilizes drinking water and when used to soften water, its action precipitates sulphate of lime, carbonate of lime, carbonate of magnesia, phosphate of lime, oxide of iron and silica. Any acidity is destroyed and any iron is deposited at one of the electrodes.

This process, while patented, is not a secret one and the Electric Water Purifying and Filter Co., of 25 Broad St., New York City, invite the most rigid investigation and will be pleased to send a pamphlet containing a descriptive statement, analysis and reports to any reader of THE PRACTICAL ENGINEER.

Loomis-Pettibone Gas Generating Plants are attractively described by means of diagrams and colored plates in a new pamphlet that is being issued by the Power and Mining Machinery Company, Milwaukee, Wisconsin. This system gasifies Bituminous Coal, Wood, Charcoal, Lignite, etc., and produces a gas that is particularly adapted to the operation of gas engines. The Water Gas made by this system can be used separately in various feeding work, such as forging, welding, tempering, etc. This pamphlet can be had upon application to the Company.

The Gandy Belting Co., Baltimore, Md., have an interesting booklet which tells about Gandy belting, which they will send to any engineer mentioning this paper.

A monthly stock list of second-hand boilers, engines, dynamos, motors and other machinery is issued by Wickes Brothers, 137 Liberty St., New York City. The list is printed in booklet form and describes briefly the immense amount of second-hand machinery carried by this popular firm. It is a good thing to have in hand in case of accident. A copy will be mailed to anyone mentioning THE PRACTICAL ENGINEER.

Grapho is a preparation for improving the quality of lubricating oils; it is said to be very effective. A sample will be sent for trial, upon receipt of request, to Grapho Mfg. Co., Corner of Frank and Commercial Sts., Rochester, N. Y.

Nugent's treatise on "How to Oil an Engine" contains much that is good to know and is well worth writing for. It will be sent free to any reader of THE PRACTICAL ENGINEER, upon request. Address, W. W. Nugent, 26 West Randolph St., Chicago, Ill.

Sturtevant economizers, built with metal-to-metal joints in the staggered pipe system, by B. F. Sturtevant Co., Boston, Mass., are being installed by the Bergenport Chemical Works, Constable Hook, Bayonne, N. J.; Municipal Electric Plant, Burlington, Vt.; Orford Copper Co., Constable Hook, Bayonne, N. J.; Firth-Stirling Steel Co., Giesboro Manor, D. C.; Consolidated Railway Co., New Haven, Conn.; Norfolk and New Brunswick Hosiery Co., New Brunswick, N. J.

GRAPHO

SOMETHING NEW

A new preparation for enriching oils.
Will suspend in oil.
No more Hot Journals.
Engineers who have tried same claim it to be the best yet.

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A trial will convince you
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A complete set for every size of pipe in your plant will save many a dollar. Quickly applied while pressure is on the pipe WE GUARANTEE TO STOP THE LEAK. Steel or brass, all sizes, ¼-inch to 20-inch. No trouble to send further information.

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The New 33,000 H. P. Power House

of the Philadelphia Rapid Transit Co., one of the largest and most prominent street railway concerns in the world, operating the entire street railway system of Philadelphia,

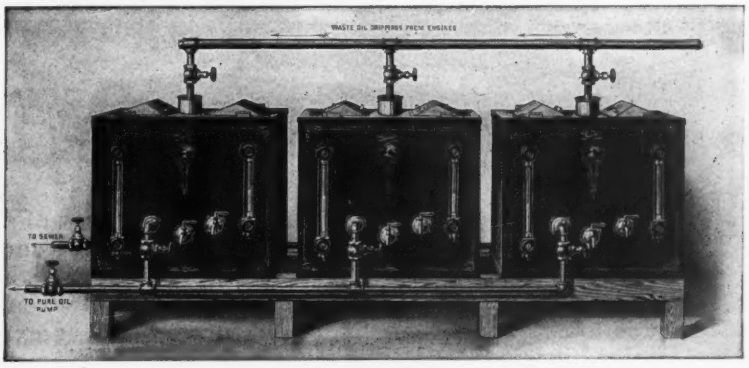
Is Equipped with "American" Unit Oil Filters

This new power plant was designed to eclipse any similar plant in the world in points of modernness and efficiency, and the fact that "Unit" Oil Filters were selected, after an exhaustive but unsuccessful search among the various makes on the market for something better substantiates our claim of superiority for the "Unit." Their first order was for Six "Units." After a trial

An additional order has been placed for four "Units"

making ten in all. No comment on this action is necessary. It is sufficient evidence that no more scientific or efficient oil filter than the "Unit" exists.

The "Unit" is the result of 15 years' endeavor to perfect an oil filter, during which time we have made and sold over 20,000 filters. Each "Unit" is 42 inches long, 28 inches wide and 36 inches high, having a filtering capacity of from 175 to 225 gallons in 24 hours. "Unit" can be operated with or without oiling system and is so constructed that any number of "Units" can be operated together or separately. Additional "Units" can be installed when conditions demand it.



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They are guaranteed to clean the heaviest as well as the thinnest oils perfectly. They possess features not claimed for any other make, which are fully described in our new 48-page catalog—the most complete and most interesting book ever issued by any oil filter manufacturer.

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Two "Unit" Filters have been installed in the new office building of John D. Rockefeller (Standard Oil Co.) in Cleveland. The Standard Oil Co. have 73 of our filters in use in their own pumping stations.

"Units" are used by the Baldwin Locomotive Works and The Calumet & Hecla Copper Mining Co., the largest copper mining concern in the world.

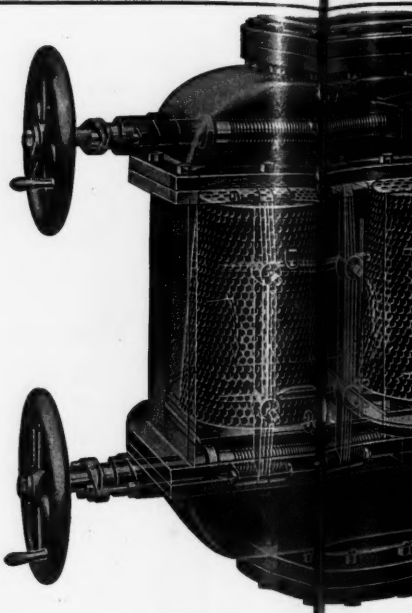
Send for list of large concerns who are using "Unit" Filters.

***The* Burt Mfg. Co.** **Largest Manufacturers of Oil Filters in the World.** **204 Main Street, AKRON, OHIO, U. S. A.**

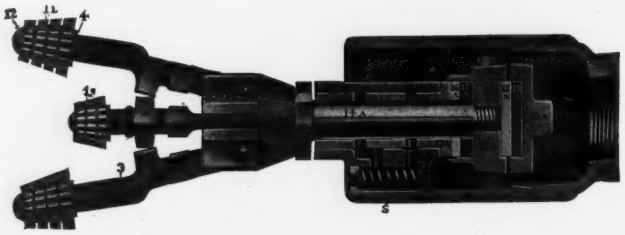
Also Supplied by Engine Builders, Dealers, and Power Contractors

Carried in stock by Shelby & Co., 66 Leonard Street, London, E. C., England, Sole Agents for Great Britian.

THE TWIN



The Twin Strainer is for removing all kinds of foreign matter from the water supply such as stones, chips, leaves, small branches, fish and other undesirable matter. It is especially valuable on boiler feed lines and on every pump suction line and condenser or any place where it is necessary to strain any kind of liquid continuously. No other device has ever been invented that offers such perfect protection to your pumps, condensers and other machinery, and as a preventative of expensive shut downs.



A Liberty C
for Hard Se

The Liberty is rapidly replacing all other types of boiler tube cleaners. Within the last week it has replaced seven machines of another make in a large plant in Pittsburg, because at the end of a week's competitive run the Liberty Cleaner was in practically as good condition as it was when it started, while its so called competitor had been built over four times at an expense equal to the first cost of the Liberty. The labor expended per tube cleaned with the Liberty was about half of that required to operate the other machine.

The results of this test prove that the Liberty Cleaner pays for itself in cost of repairs in one week's run, the 50 per cent saving in labor being a clear profit.

This is
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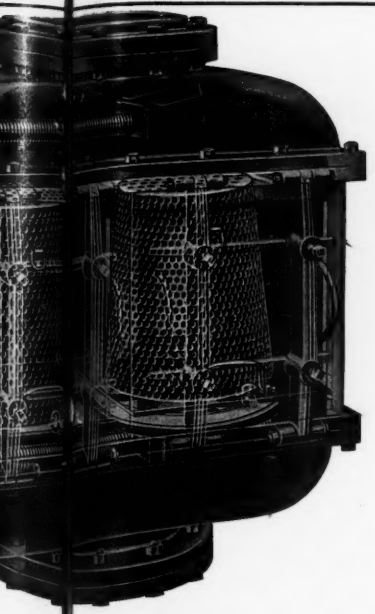
with a
manufa
any rep
It is on
for you
over al

LIBERTY FAMOUS OIL FILTER

Lubricating oil can be "strained" through almost any old thing and some of the largest chunks of grit and dirt will be removed, but that is not **filtering.** The Liberty Famous Oil Filter filters thoroughly and scientifically by the jacket temperature treatment. **A dry process,** no water is used in contact with the oil. It is the only scientifically correct filter ever built for plant purposes.

ASK FOR SPECIAL FILTER CATALOGUE

LIBERTY MANUFACTURING CO.,



STRAINER

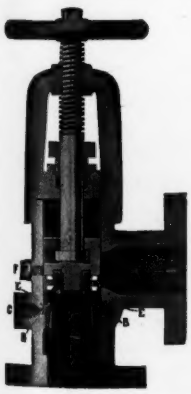
It strains continuously and is easily cleaned in a few minutes while under full pressure, either side can be thrown in or out of service by simply operating a pair of valves, the one not in use being accessible for cleaning. Another great advantage of the Twin Strainer is that it can be placed anywhere in the suction line either in or outside the building. The mesh of the removable basket shaped strainer can be as fine or as coarse as desired. Ask for SPECIAL STRAINER CATALOGUE.

rty Cleaner
rd Service.

This is a pretty good investment on the part of the manufacturer who is troubled with scale in his boiler tubes.

In a large power house in New York City the Liberty Cleaner was in competition with another type and after two week's run its competitor was sent back to the manufacturers a hopeless wreck, but the Liberty was still doing business without any repairs on the turbine proper.

It is one thing to make claims, and another thing to prove them. The best proof for you is to try a Liberty, as it will cost you nothing to find out its superiority over all others.



THE FABER BLOW-OFF VALVE

This is the Blow-Off Valve that washes its face every time before closing. It is so made that a jet of steam cleans it just as it seats, that's why it is always tight. Get one of them and your "blow-off" troubles will be over for a long time to come. Don't fool with that old leaky one until it has wasted several times its cost. Get a Faber and be happy.

6409 Susquehanna Street Pittsburg, Pa.

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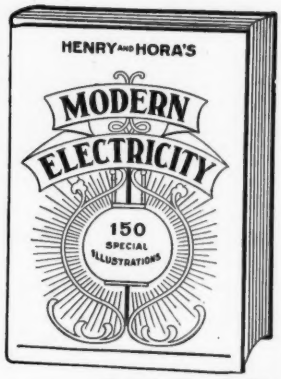

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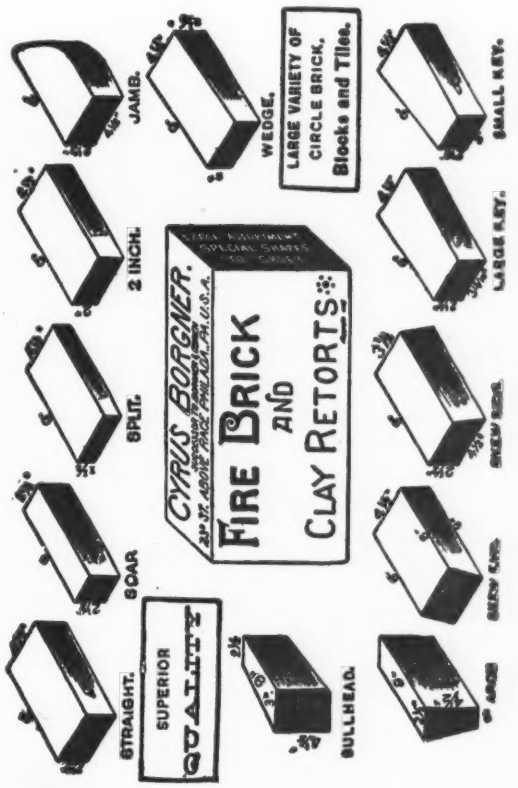
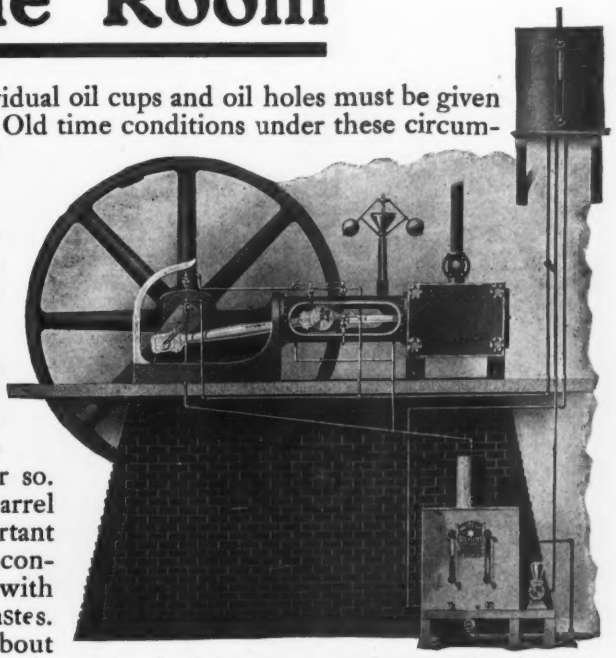


A Clean Engine Room

is difficult, if not impossible, when dozens of individual oil cups and oil holes must be given periodical attention by "the man with the can." Old time conditions under these circumstances are familiar matters of so recent memory as to need no more than mere mention.

A dirty engine room is an eyesore to the neat, yet helpless engineer, an element of special danger by fire and an evidence of waste and loss to the man who "foots the bills." This state of affairs is obviated completely by use of the



White Star Continuous Oiling System

because the lubrication of bearings is done by a steady flow of pure oil from a reservoir requiring replenishing only at long intervals—once a month or so. This periodical replenishing is made direct from barrel to the White Star Oil Filter, which is one important feature of the White Star Oiling System. Thus constant handling of oil in small amounts is eliminated, with resultant savings in stoppage of constant small wastes.

Booklet "F" which we have issued tells all about this system and points the way to oil economy and may be had by every engineer. Send for it.

Pittsburgh Gage and Supply Co. PITTSBURGH, PENNA.

D X N TRADE MARK

Engineers find Dixon's Flake Graphite of daily value for lubrication. It keeps bearings cool, saves wear and repairs and prevents frequent piston repacking. Do you use it?

Get our engineer's sample can "No. 96-C"—sent you Free on request.

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Jersey City, N. J.

LEVIATHAN

I ONCE OVERHEARD

our Manager, "J. B.", a man by the way very chary of his praise, and usually just in his censure, say this: "If we had all of the money we have put into rubber belts in the past 25 years, we would have a good round sum, and I now firmly believe that we could have saved fully one-third of that money (possibly even more) if we could have been persuaded to try "Leviathan Belting" at the start, in place of taking it up a year ago."

There are still quite a number of J. B.'s in the industrial "hive" Shall we send you a booklet?

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MICA FLAKE
FLOATED

Use it once and no other lubricant will ever satisfy you Greatest lubricant ever discovered. Try it on the worst bearing you have, or in your cylinder.

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if not properly done, in any plant, will cause the engineer a great deal of trouble, and his employer unnecessary expense. Many years of practical experience and a force of competent assistants enables me to guarantee absolute satisfaction.

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THE GENUINE
GANDY
PATENTED 1877

THE GENUINE GANDY Grips, where other belts slip.

That's the reason its such a favorite with Engineers. It keeps time with the engine and runs the machinery as it ought to be run without tearing the bearings to pieces.

Don't forget it is 50 to 75 per cent cheaper than leather, and will outlast it every time.

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BALTIMORE, MD.

McDANIEL
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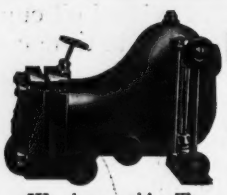

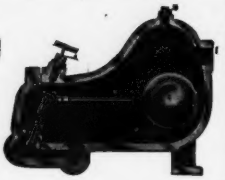

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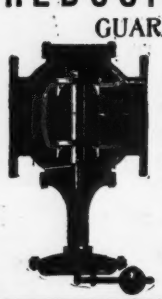

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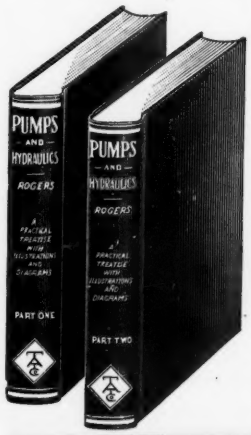

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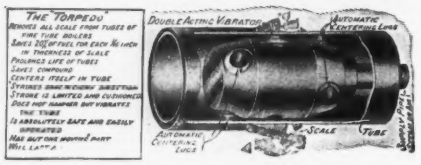
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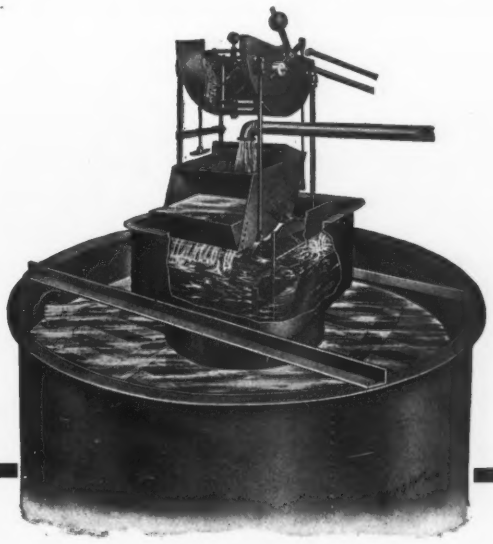

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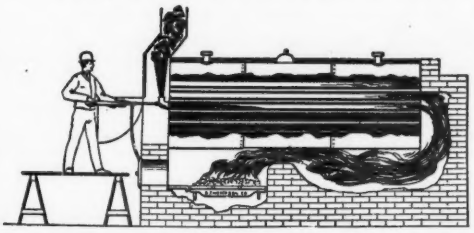

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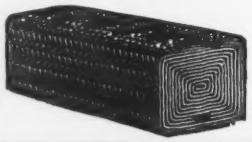

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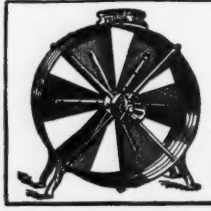

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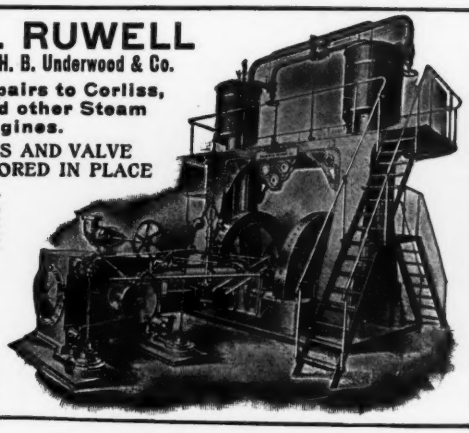

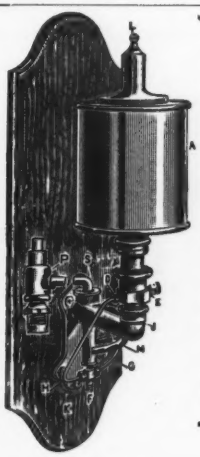

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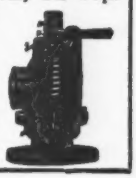

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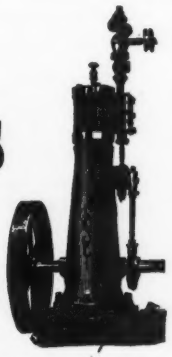

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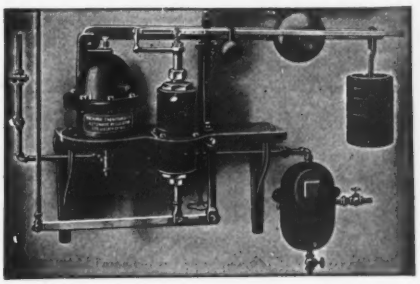

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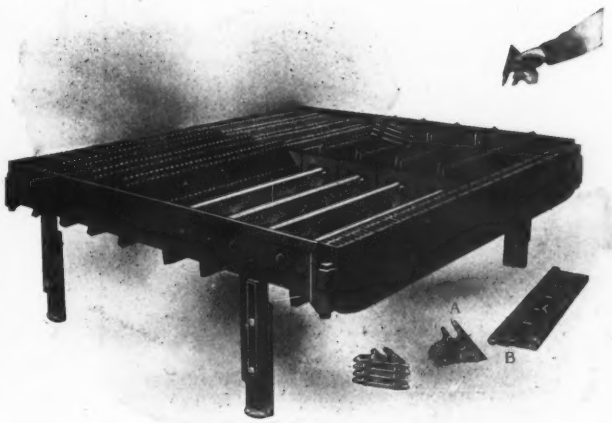

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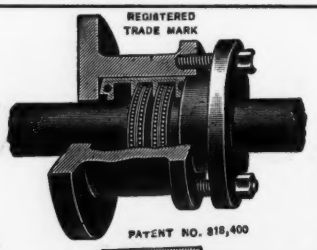

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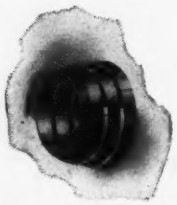

The United States Metallic Packing Co.

PHILADELPHIA AND CHICAGO

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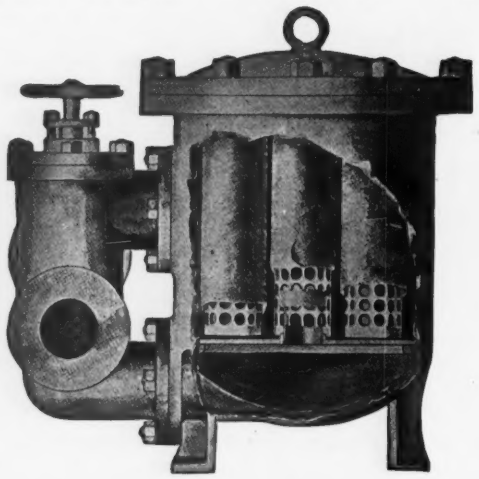
We have added several new and useful articles to our list of premiums for procuring subscribers to The Practical Engineer and we want all our engineer friends to get up a Club. Write for circular The Practical Engineer, 46 N. 12th St., Phila., Pa.

Filtered Feed Water Prevents Scale



The Blackburn Smith Patent Feed Water Filter and Grease Extractor will remove all the mud and grease from your feed water, prevent scale and save you the cost of boiler compounds and wasted fuel. Can be placed either on the suction or discharge scale of feed pump. Easy to clean. Made in all sizes. Write for Catalogue.

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A TABOR CROSBY OR AMERICAN-THOMPSON INDICATOR

Also 500 other things including every article, tool or device an engineer may want. For Free premium list and full particulars regarding this remarkable offer, fill out and mail us the coupon below.

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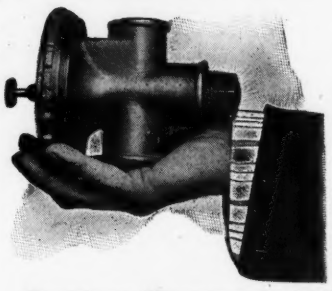
DUNHAM STEAM TRAPS



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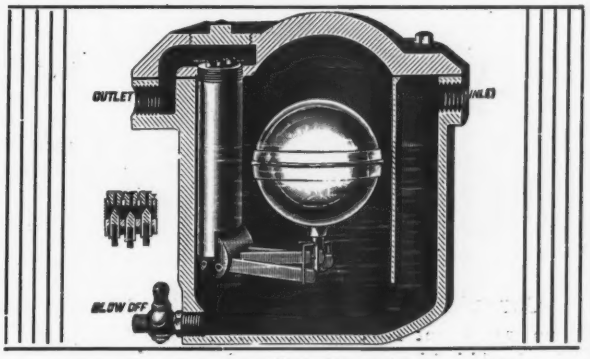
For Information pertaining to
Wright
"Emergency" Steam Traps
A POSITIVE REMEDY FOR CONDENSATION IN STEAM PIPES



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Under Small Flows or Floods of Condensation.

WATER SEAL AT INLET AND OUTLET ABSOLUTELY PREVENTS WASTE OF STEAM

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30-Days Trial will prove that Lindstrom's Liberating Valve **Steam Trap** is a wonder. **The only Successful Steam Trap.**

It takes care of itself.
No parts to get out of order.
The Valve never leaves the Seat.
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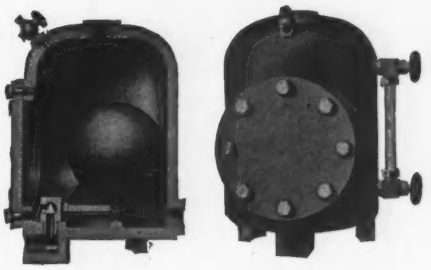

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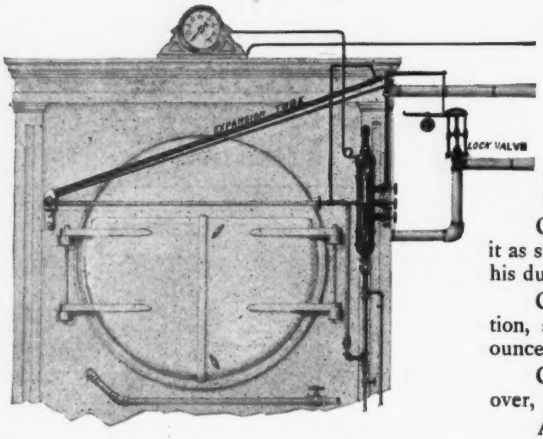

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ALL OF THEM save repairs, packing, oil, coal, time and labor.

ANY OF THEM furnished on a trial that imposes no obligation to purchase.

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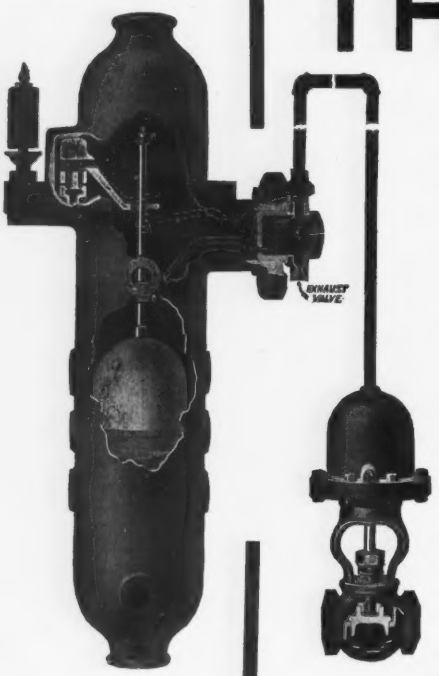
THE WILLIAMS

Safety Feed Water Regulator



insures regularity throughout your entire steam plant. If your boilers are fed regular with the water always at the same level, they will be fired regular and we all know that regular firing means economy in fuel and less repairs.

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If the Williams did nothing but prevent accidents and shut downs it would be an excellent investment, but it also saves enough in fuel and repairs to pay for itself many times over.

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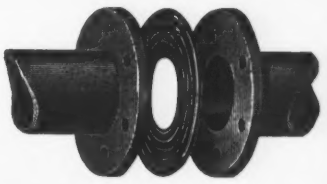

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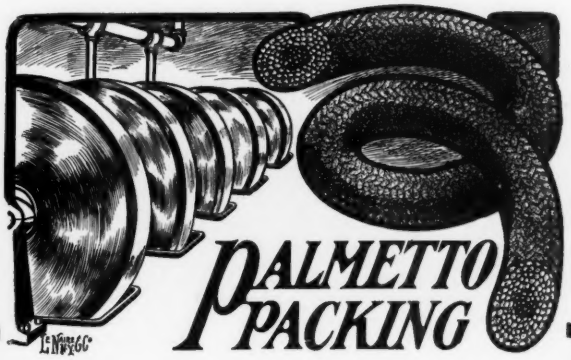

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The higher the pressure and temperature, the more you need Palmetto. Sample sent free.

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Piston Actuated Pump Governor

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is controlled solely by the discharge pressure from the pump and is unique in several important features. Noiseless in operation it is guaranteed to give better, closer and longer continuance in service than any other piston actuated pump governor in the market.

Ask us about Foster "Class W" High Pressure Regulator Free Exhaust Valve, Non-Return Stop Valve, Low Pressure Valves, Back Pressure Valves, etc.

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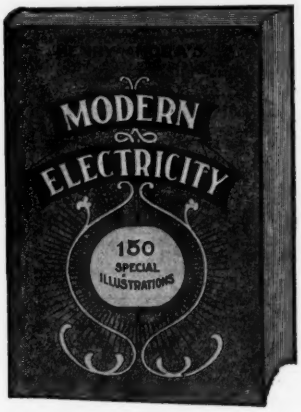
BY HENRY & HORA



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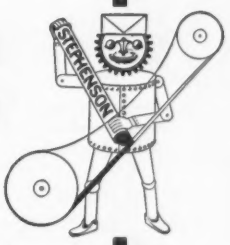

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"FORCE-FEED is the only positive lubrication"

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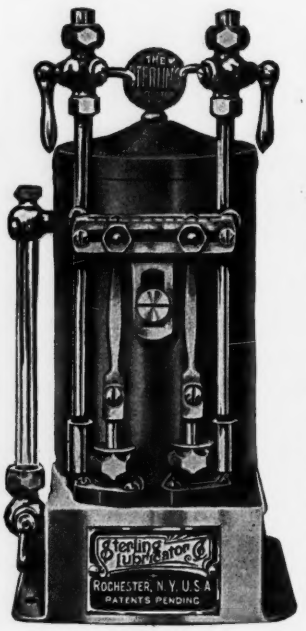

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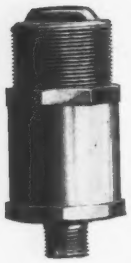

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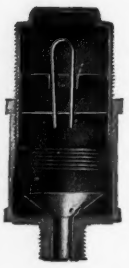

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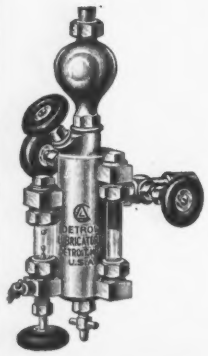

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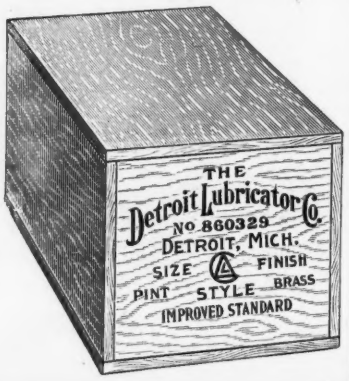

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It looks bad, reflects on your standing, makes people think you can't afford a stenographer, and is sometimes ambiguous.

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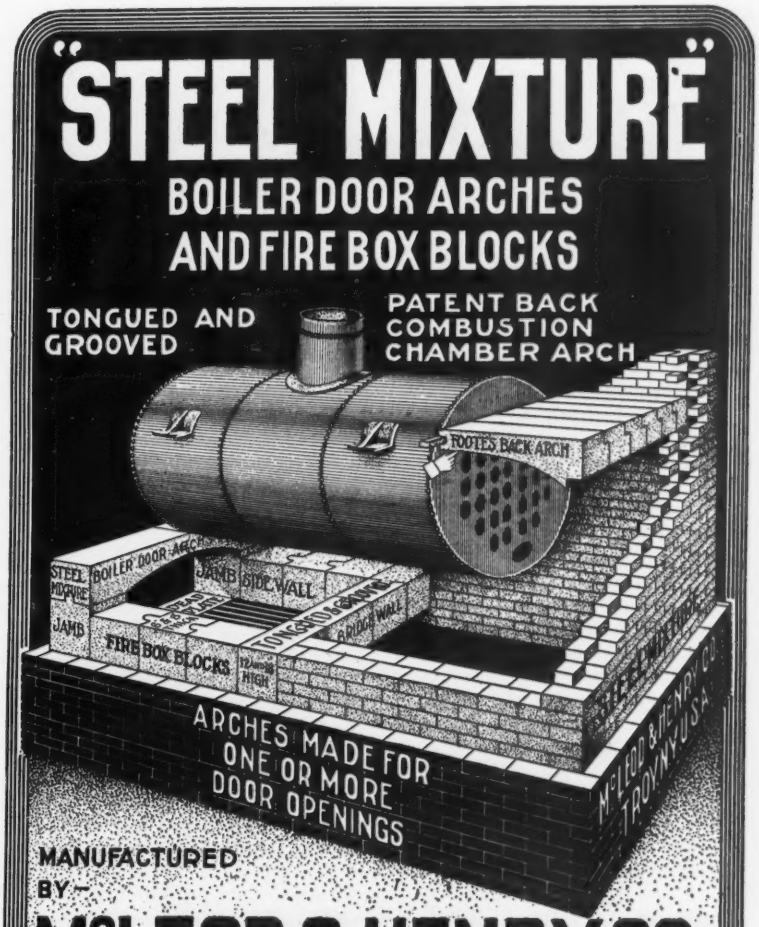
BOILER DOOR ARCHES AND FIRE BOX BLOCKS



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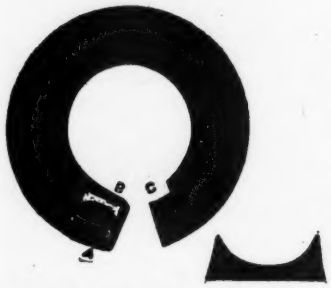
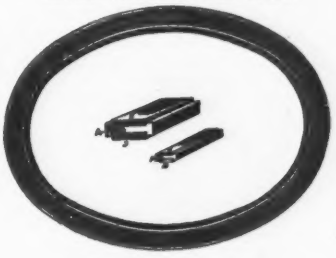
Walsh Metal Face Packing



A—Fibrous Packing. B—Metal.
C—Open space to avoid butting when cover is worn off.
D—Section of metal cut out at C.

Walsh Combination Gaskets

WILL NOT BLOW OUT



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The Cheapest Gasket Made.

A—Soft Metal. BB—Rainbow Rubber. Composed of Soft Metal and Rainbow Rubber as shown in cut. Made different widths and thicknesses for man and hand hole Gaskets.

Adapted to all kinds of Steam and Water Packing. Will not cut Rods, will not wear rods to shoulder, will not harden under compression. More durable than fibrous packing. Less friction, as it is lubricant of itself. For packing engines, steam hammers, cranes, valves, expansion joints, pumps, elevators, accumulators, hot-water plunger pumps, etc. **Cotton, Linen and Square Flax Packing in Stock.**

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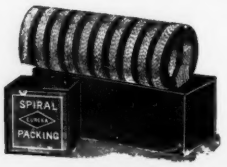
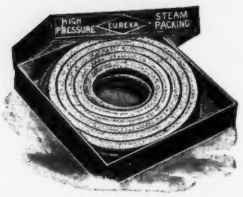


EUREKA SPIRAL



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We honestly believe them to be superior, just as "EUREKA GUM CORE" proved superior for nearly a quarter of a century.

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If a square flax is wanted, say EUREKA SQUARE FLAX.

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For cold water purposes, pistons of pumps, hydraulic elevators, etc., ask for EUREKA WATER PROOF PACKING.

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Ask your dealers to furnish you samples of every one of the packings we make. Try them, or write to the

EUREKA SQUARE FLAX

EUREKA AMMONIA

THE EUREKA PACKING CO., Sales Dept. P.
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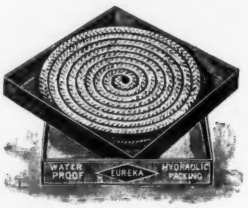

EUREKA WATER PROOF

If you are in need of an Indicator, Reducing Wheel, or a Planimeter, write for the easy terms we make, and the low cash prices we ask for the Robertson-Thompson Indicator, A Victor Reducing Wheel, and a Willis Planimeter.

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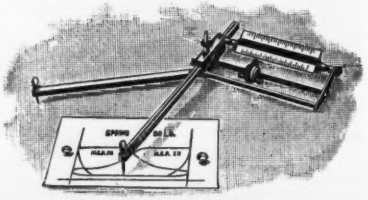
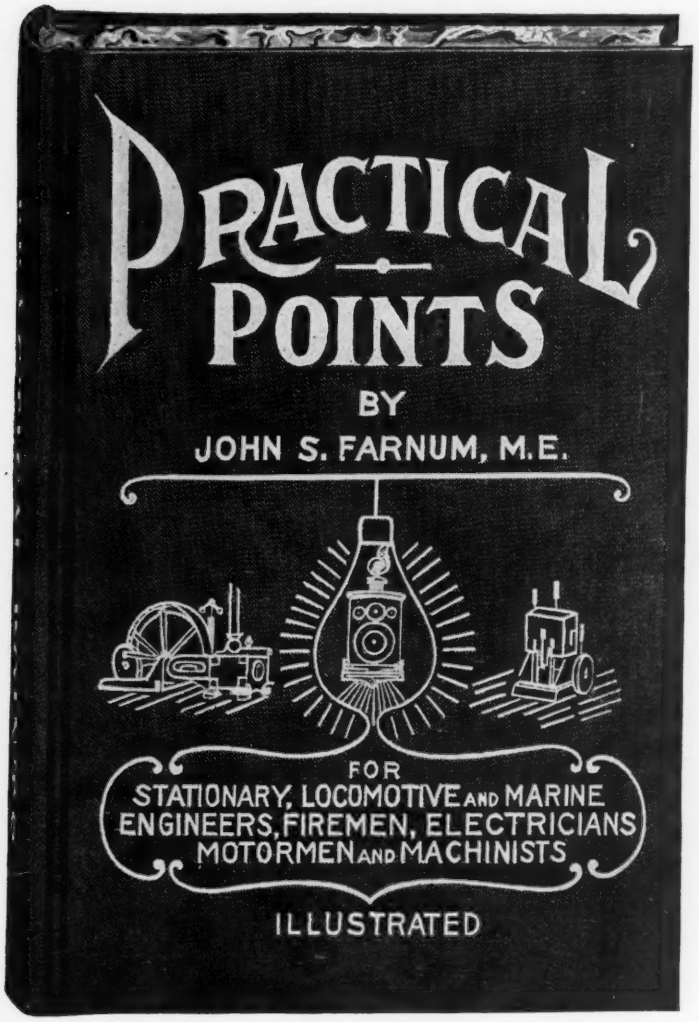


The Willis Improved Planimeter



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CUT OUT the coupon below and send it to us with the scale.

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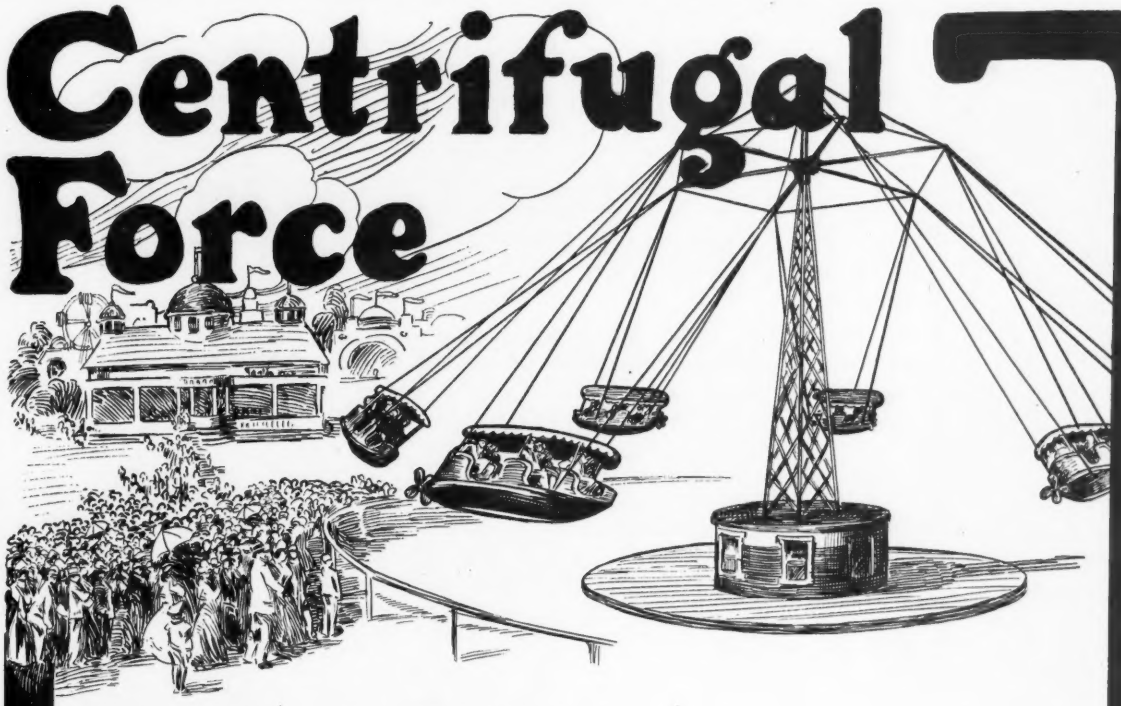

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truly illustrates the principle of centrifugal force—the force that separates the water from the steam in the

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THE SEPARATOR WITHOUT FAULT

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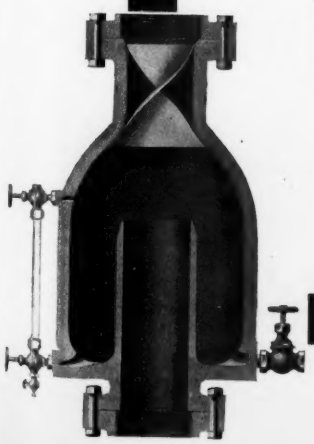

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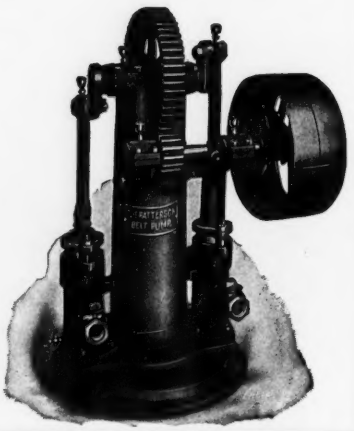

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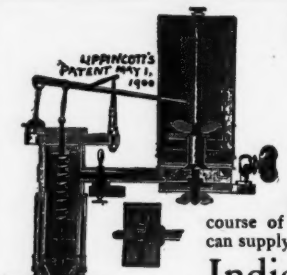

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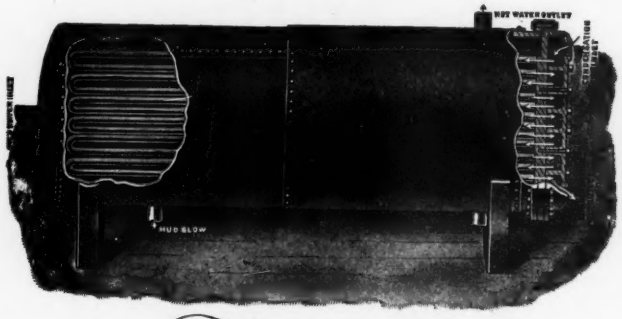

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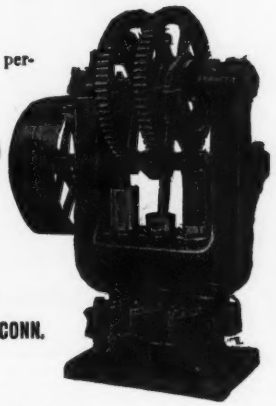

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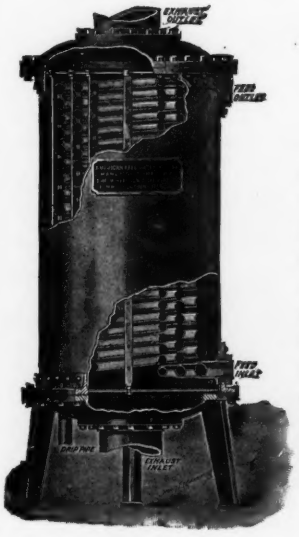

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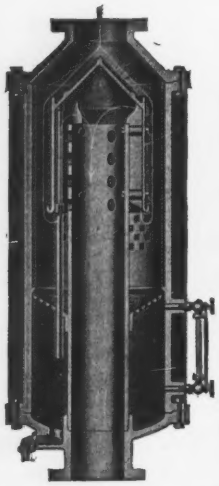

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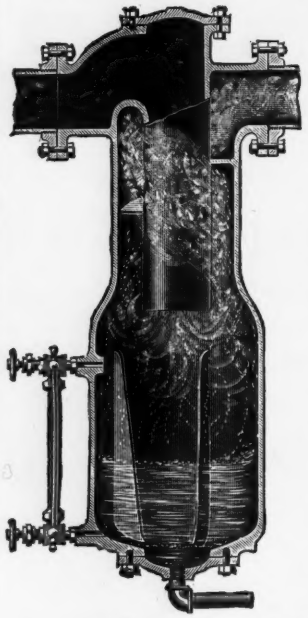

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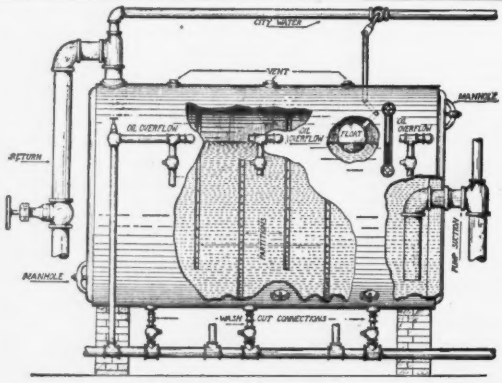

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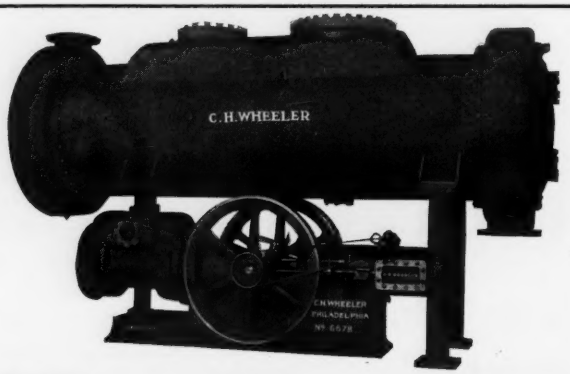

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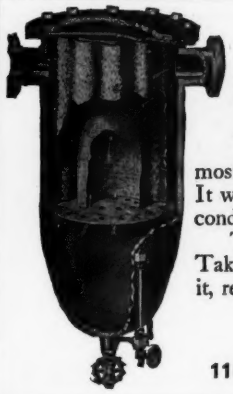

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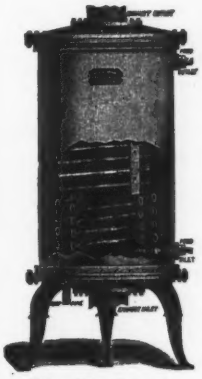

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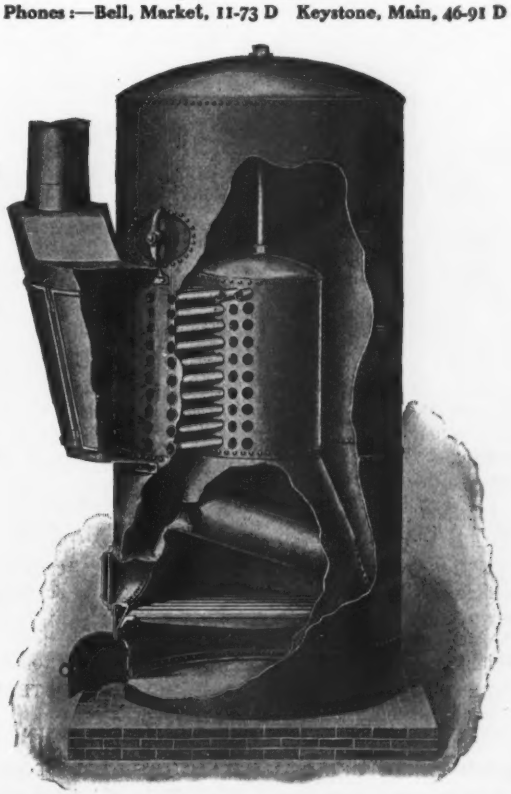

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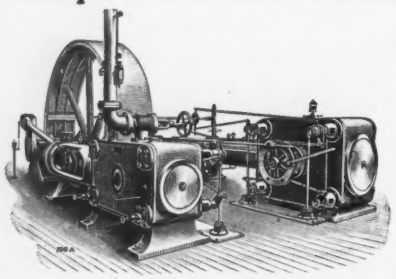

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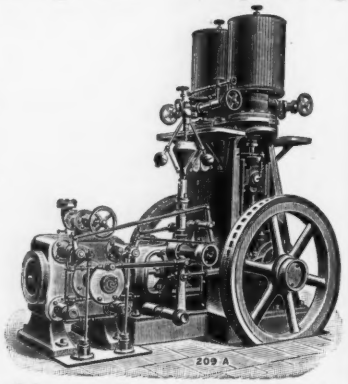

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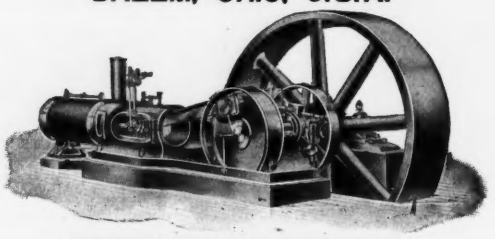

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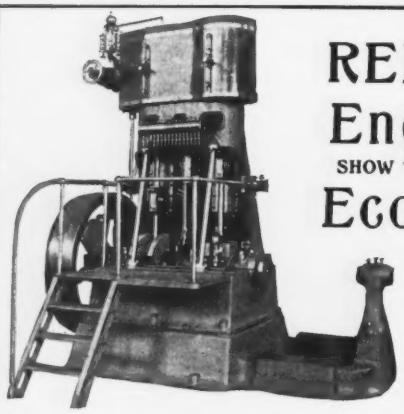

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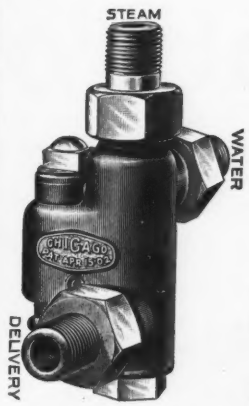

Chicago Automatic Injectors

The injector with a record of remarkable achievements.

The CHICAGO has proven that it is the best Automatic Injector on the market, as thousands of engineers and Steam users will testify.

Simple in construction, easy to operate, made strong and durable.

Write for our descriptive catalogue of injectors, ejectors, lubricators and high grade steam specialties.

The Ohio Injector Company
Largest Manufacturers of Injectors in United States
2128 MAIN STREET, WADSWORTH, OHIO

ELEVATOR REPAIRS

YOU HAVE ELEVATOR TROUBLES. WE HAVE EXPERIENCE. LET'S SWAP.

Keystone Elevator Inspection & Repair Co.

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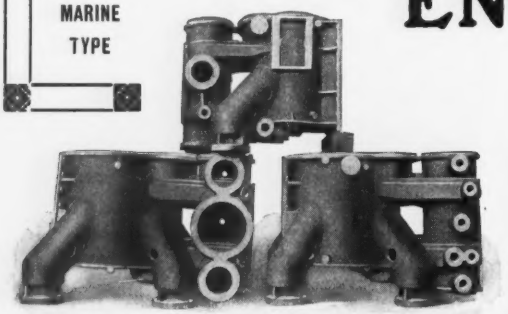
BELL PHONE—FILBERT 2258 KEYSTONE PHONE—MAIN 10-06

MARINE TYPE



ENGINE CYLINDERS

O-H-STEEL

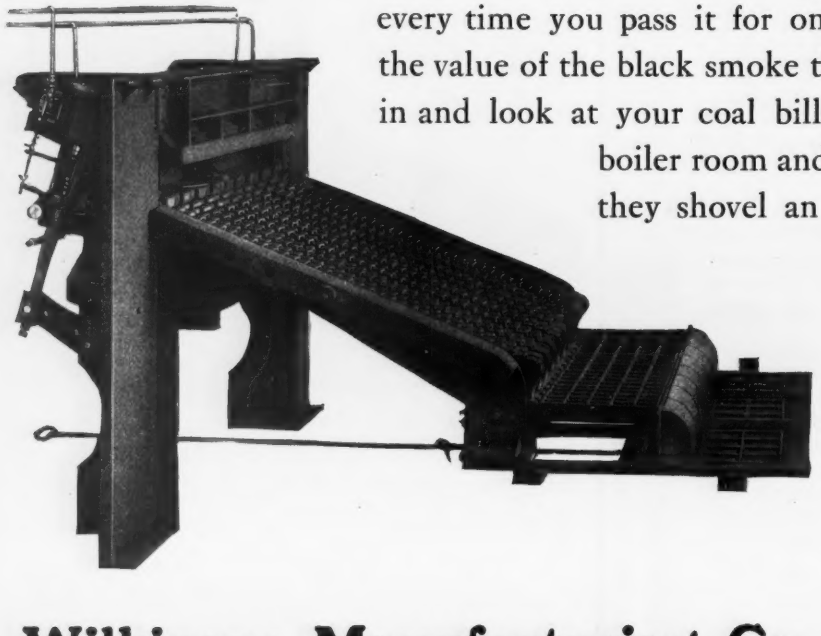
HIGH PRESSURE

PIPE FITTINGS

THE JACKSON BELT LACER

BIRDSBORO STEEL FOUNDRY & MACHINE CO.
BIRDSBORO, PA.

Look at your Chimney



every time you pass it for one month and try to calculate the value of the black smoke that is rolling away. Then go in and look at your coal bills. Then go down into the boiler room and see the fireman sweltering as they shovel an unnecessary amount of coal with fire doors wide open. Then go and look at a plant equipped with

Wilkinson Automatic Stokers

That's all, except our address

Wilkinson Manufacturing Co., Bridgeport, Montgomery County, Pa.

GET ONE FREE

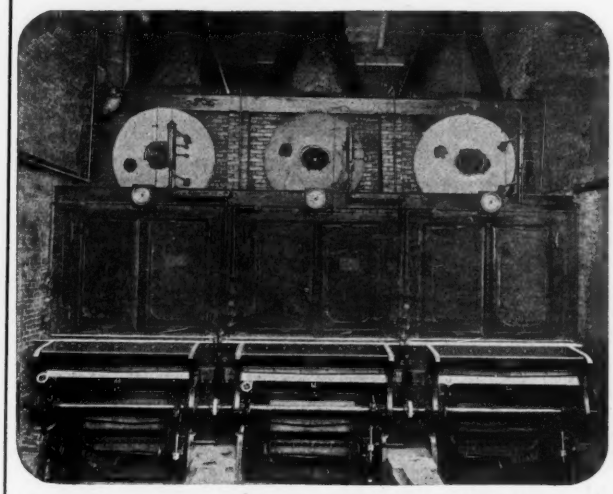
Put it on your boiler, and give it a good trial for a month; if it gives you absolute satisfaction, keep it, and pay for it, otherwise send it back at our expense.

"P. B. H." WEIGHT GAUGE COCK

There is but ONE renewable part; the special metal valve pencil, which lasts for years and can be replaced for a few cents, in a minutes time. Thousands in use. Absolute satisfaction on high pressures.

THE PAUL B. HUYETTE CO., Inc. 1245 BETZ BUILDING PHILADELPHIA

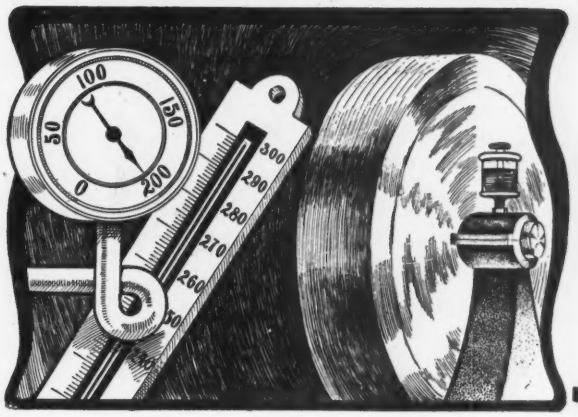
The Wetzel Stoker



With hand firing, all three of the boilers shown above were required to operate the plant. Since installing the Wetzel Mechanical Stokers two of the boilers do the same work with less fuel, less labor and no smoke. Just read that over again and then **write for our Catalogue.**

THE WETZEL MECHANICAL STOKER CO.
147 East State Street, Trenton, N. J.

HARRIS OILS



Are your lubricating oils giving satisfaction? If you have any doubt about it, we have a plan whereby you can test them as to efficiency and economy at our expense, in comparison with Harris Oils.

We furnish superior lubricating oils for every purpose, high speed, high temperature, high pressure, or low pressure and low temperature.

Their excellence and the fact that each is specially adapted to meet every condition of its employment, ensures their economy.

A small quantity produces the best results in lubrication.

Every Harris Oil represents a study of the requirements of the type of engine or class of machinery it is to lubricate.

All details as to pressure, temperature, speed of moving parts, and method of lubrication are carefully considered.

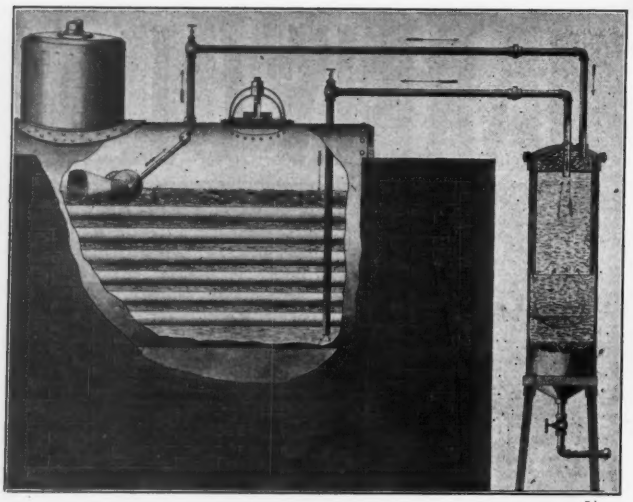
If the question of lubrication, upon which the efficiency of your plant so largely depends, interests you, consult our catalog of lubricants, or better still, write us for particulars regarding the proposition we are prepared to make to users of lubricating oils.

A. W. Harris Oil Company

320 South Water Street, Providence, R. I.

Pacific Coast Agents.

Tatum & Bowen, 36 Fremont St., San Francisco.



It Floats

All of the mud and other impurities in the boiler feed-water that combines to make scale come to the surface at some time while the water is boiling and is caught up by the floating skimmer and carried off to the filter from which only the pure clean water, still hot, is returned to the boiler. It removes all the impurities all the time and at no expense after it is installed. Isn't it better than buying barrel after barrel of compound, or permitting scale to accumulate and then buying expensive boring machines or worse still allowing the scale to remain and buying coal to drive heat through it.

The Buckeye Automatic Boiler Skimmer

is the only genuine Automatic Boiler Cleaner that does its work without chemicals or other assistance. It is absolutely automatic, the skimmer is always floating exactly on the surface and therefore always doing its full duty. It is the only **floating skimmer** on the market.

We install them on trial and guarantee absolute satisfaction or no pay.

WRITE FOR CATALOGUE AND PRICES

THE BUCKEYE BOILER SKIMMER CO., COLBURN AVENUE, TOLEDO, OHIO

ZENA

Is the toughest, most elastic and most pliable packing made.

It will keep worn rods and plungers tight when all other packings fail. It will stand HIGH PRESSURES and HIGH TEMPERATURES and will hold and wear longer than any other packing.

The material of which it is made is of a highly superior quality and the core never looses its resiliency. It will pack steam tight with less friction than any packing we have ever seen before.

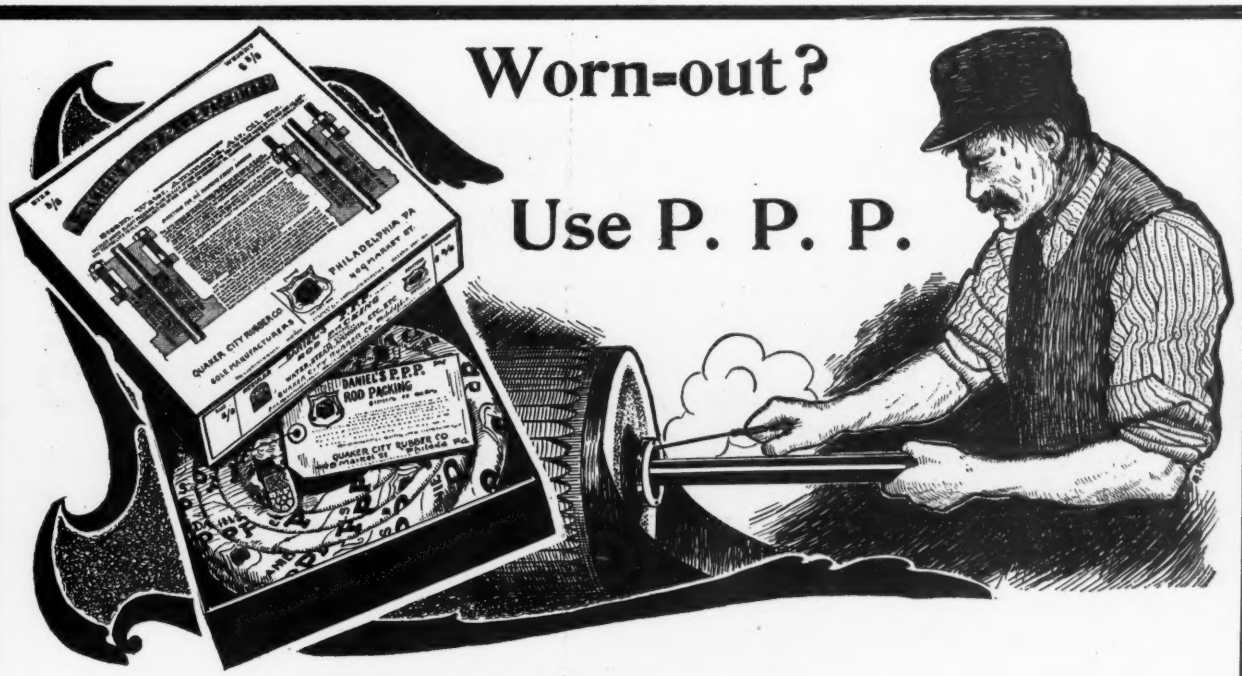
A few turns of ZENA used in connection with any packing you now have will improve that packing greatly.

TRY IT, AND YOU WILL BE A FRIEND OF ZENA FOREVER.

WRITE FOR PRICES AND FULL INFORMATION

RANDOLPH BRANDT

70 CORTLANDT STREET, NEW YORK CITY



When the old style solid packing wears out—

Use P. P. P.

Use it as directed and you'll see the difference between a well made, scientifically constructed packing and other kinds.

There is nothing so good as P. P. P. at any time, but in hot weather time it's a treat!

Pack with P. P. P. now and probably all summer you'll be free from stuffing box troubles.

Think what this means to you—no working after hours and Sundays in the hot engine room when you should be enjoying life out doors. Why it's like a summer vacation with P. P. P. in the stuffing box.

And remember this—the way P. P. P. cuts down Engine room expenses by saving Power and Fuel and lasting often ten times longer than old style solid packings—or worthless imitations of P. P. P.—makes it a great favorite with your employer. He will appreciate your using P. P. P.

Read this letter. Nearly every day we receive just such expressions of gratitude for the good work of P. P. P.

"Used P. P. P. in a Brownell Automatic Engine running 23 hours a day. Did not have to use an extra ring for a year and a half.

I consider P. P. P. the best packing on the market.

H. F. KINNAN, Eng.
Acme Pottery Co., Crooksville, O."

Now which will you decide to do—work over the old or enjoy the new? Our booklet proving that P. P. P. saves you work will help you to decide. Send us the coupon to-day

Quaker City Rubber Co.
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The **Quaker City Rubber Co. Philadelphia**

Gentlemen :—Please send me your booklet proving that P. P. P. will save work.

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ESTABLISHED 1870.

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ST. JOHN SELF ADJUSTING
CYLINDER PACKING.

H. B. UNDERWOOD & CO.

GENERAL MACHINISTS,

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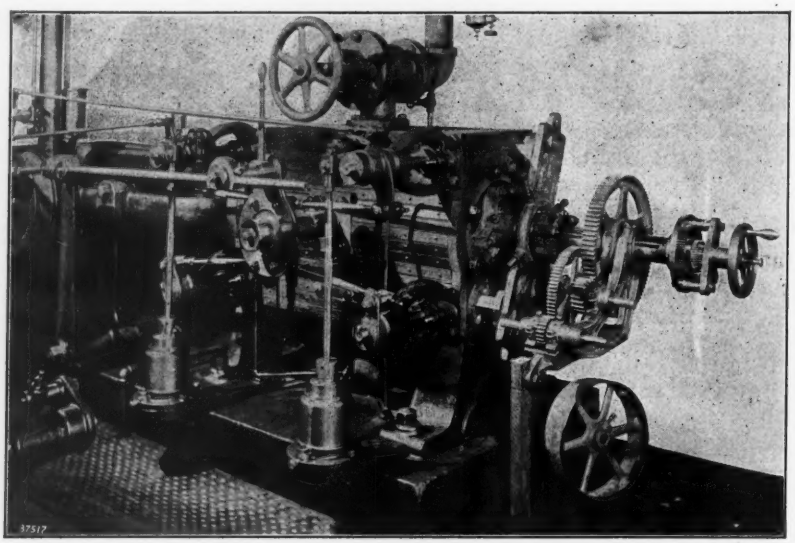
WHEN your cylinder needs reboring or your valves need reseating, you don't have to dismantle your engine and send it away. We have a complete line of *Portable* tools for this kind of work, and instead of bringing the engine to the tools we move the tools to the engine, thus saving both time and expense.

We rebore cylinders of any size in position, and we have a special machine for reseating valves in position from 1 to 12 inches in diameter.

We have made a specialty of this class of work for many years and we now have the most complete line of tools and the best force of expert mechanics to be found any where in the country.



THE UNDERWOOD WAY

We make all kinds of repairs to all kinds of steam engines, steam pumps steam hammers and general machinery.

We send men and tools to any part of the country on the shortest possible notice. Our motto is "Quick service and highest quality."

The Kitchin Disengaging Hook should be applied to every engine of the Corliss Type. It can be applied to right or left hand engines, vertical or horizontal without change. It provides the best possible working connection and the simplest and most convenient disengaging operation. It is operated with one hand and requires no special skill or attention. Send for special circular describing this excellent device more fully.

We also make a specialty of gear cutting, internal and external, up to 36 inches diameter.

Portable Milling Machine for Milling off Valve Seats in Position
Ice Machine Repairs a Specialty.
Sole Agents for St. John Self-adjusting Cylinder Packing.
Crank-shaft Journals of all sizes turned off without removal.
Send for Our Book of Useful Hints for Engineers.

Dynamo Commutators Turned Off Without Removal.
Builders of Dash Pots.
Portable Planer for Facing Off All Sizes of Hammer Blocks in Present Position.
Blacksmithing. Steam Power Hammer.

Keystone Grease

"The World's Greatest Lubricant."

Thousands of engineers look upon Keystone Grease almost in the light of the literal meaning of the word "Keystone". Knowing the trouble they have had, and knowing what Keystone Grease will do, they feel that without it, disaster would overtake them.

Keystone Grease will lubricate properly the lightest of spindles or the heaviest, most ponderous crushing machinery, no matter if the parts are exposed to weather conditions, extremes of heat or cold, the highest internal temperature, or any other exacting demands. In fact, Keystone Grease does more than lubricate, it prevents wear and tear. One pound wil last longer than three to four pounds of any other grease or four to six gallons of high grade oil.

Now test what we say. We will send to any engineer a large size sample can, a heavy brass grease cup, and an engineer's cap. We send these FREE (no charge now or afterward). All we ask is the size of tap, H. P. of engine, R. P. M. of bearing, and that the engineer will give Keystone Grease a thorough test.

KEYSTONE LUBRICATING CO.

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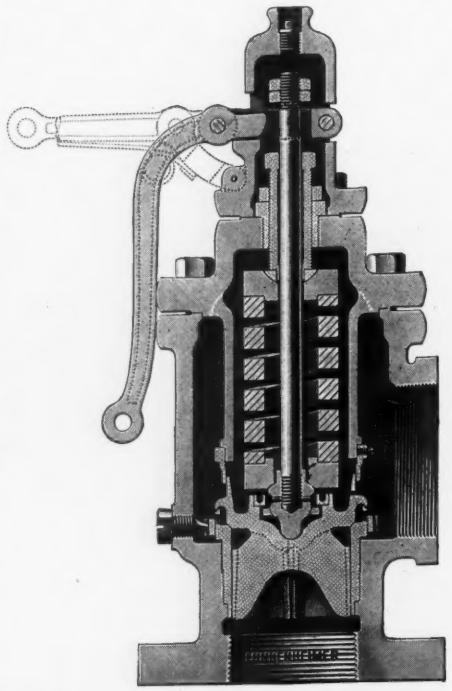
1102 Tacoma Bldg., Chicago, Ills.



LUNKENHEIMER "Pop" Safety Valves

VERY SENSITIVE TO EXCESSIVE PRESSURES

NO BOILER SAFE WITHOUT ONE

MADE ENTIRELY OF BRASS OR IRON BODY BRASS MOUNTED AND IN STANDARD SIZES

If Your Local Dealer Cannot Furnish them, notify us

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Largest Manufacturers of High-Grade Engineering Specialties in the World.

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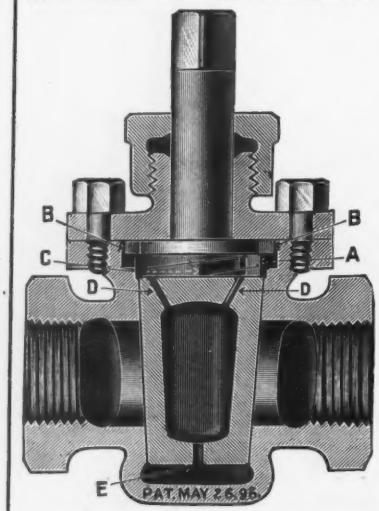
We Manufacture a Complete Line of Brass and Iron Globe and Gate Valves, Mechanical and Hydrostatic Lubricators, Oil and Grease Cups, Injectors, Ejectors, Whistles, Water Columns, Gauges, Pop Safety and Relief Valves, Etc.
11 P. E.

Homestead Valves

are built for hard service and satisfaction.



The Homestead Straightway Valve shown herewith is so constructed that when it is closed it is at the same time forced firmly to its seat. It doesn't leak or stick. No better valve was ever made. It is made in all sizes up to 6 inches and for all pressures up to 5000 lbs. per sq. inch.

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DO YOU WANT TO MAKE MONEY?

NO HOT AIR. NO HOLES IN THE GROUND.

A few shares of the stock of a company for sale at par, $1.00 which will enable you to participate in the profits derived from the handling of a number of inventions.

WRITE FOR INFORMATION

INDUSTRIAL ENGINEERING CO.

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Powell

IS THE NAME COUPLED WITH STEAM BRASS GOODS FOR YEARS

When in the market for Oilers for your Engine or machinery, it pays to get the best and the BEST is the **POWELL SIGNAL** as reconstructed.

Its the original
Lever up—open—oil dropping
Lever down—shut—oil stopped

Convenient to fill, easy to regulate. When once the required rate of feed is obtained, it need never be disturbed. It is an oil saver, none of it goes to waste and that means money in the pocket of the user. A first class reliable oiler in the full sense of the word.

We make other styles, send for catalogue and circular describing same.

***The* Wm. Powell Co., Cincinnati, O.**

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INDESTRUCTIBLE WHITE SHEET PACKING

OH FOR A FLANGE PACKING THAT WILL NOT BLOW OUT.

HERE YOU ARE OLD MAN, INDESTRUCTIBLE DONT BLOW OUT. USE IT AND FORGET THE PAST.

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DEARBORN TREATMENT will positively keep your boilers clean and well preserved.

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If you have not adopted Dearborn Water Treatment as thousands have done, send us gallon of water for analysis and proposition.

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